AN ENVIRONMENTAL EVALUATION METHODOLOGY FOR IMPROVING RESOURCE ALLOCATION DECISIONS: A TREATISE WITH SELECTED SOUTH AFRICAN CASE STUDIES

by

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ABSTRACT

This dissertation addresses the problem of how to manage environmental resources to improve the prospects that resource allocation activities will make the greatest possible contribution to social well-being. The study had two major aims. One aim was to provide a rational philosophical framework for guiding resource evaluation and decisionmaking processes. The second - and principal - aim was to develop a reliable and practical method for evaluating those resource allocation proposals which are particularly controversial.

As part of the philosophical framework, a modification of the social welfare function is specified which explicitly addresses the well-being of future generations. This form of the social welfare function is based on certain *a priori* premises, which are used to define the goal and objectives of resource allocation, and to identify appropriate evaluation criteria. These evaluation criteria are then used to devise a resource management strategy and to develop an environmental evaluation methodology to serve that strategy. The methodology consists of both formal and informal methods of evaluation, but special attention is given to developing a formal method of evaluation that is simple and inexpensive to apply, and therefore particularly suited for Third World conditions.

The principal research objective was to develop a useful method for evaluating those resource allocation proposals which are especially controversial. The method that has been developed - the Panel Evaluation Method - utilizes a cost-benefit framework and employs procedures modeled on the Delphi Method. The Panel Evaluation Method features three techniques for accomplishing a formal evaluation of competing proposals: the Impact Identification Technique is used to identify and define all the impacts of concern; the Significance Measurement Technique is used to judge the relative significance of the impacts; and the Criteria Trade-off Technique is used to determine which proposal best satisfies specified evaluation criteria.

The Panel Evaluation Method was applied to several case studies with positive results. For example, the central feature of the method - the Significance Measurement Technique - was found to be capable of producing reasonably replicable results, and so is considered to provide an acceptable way to determine whether the costs of a proposal would exceed its benefits. The method thus serves to extend the capabilities of both Environmental Impact Assessment and Cost-benefit Analysis, and to link these two widely-used tools for guiding resource allocation decisions into a more powerful and versatile decisionmaking tool.

Key Words: Cost-benefit Analysis; Delphi Method; environmental economics; environmental evaluation; Environmental Impact Assessment; evaluation criteria; evaluation methodology; impact identification; Integrated Environmental Management; impact significance; panel evaluation; resource allocation; resource decisionmaking; resource management; scaling; significance measurement; South Africa.

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SYNOPSIS

This dissertation addresses the problem of how to manage environmental resources, including unpriced environmental services provided by nature, so as to obtain the greatest benefit for society. A special challenge was to develop a way to judge the value of "unpriced" impacts from resource allocation activities so that more rational trade-offs could be made with priced goods.

The study had two principal aims. The first was to devise a philosophical framework to provide general guidance for making resource allocation decisions. The second was to develop a method of evaluation to provide special guidance for those situations when resource allocation proposals are especially controversial, either because of great complexity or because great significance is attached to the outcome. Most of the research effort was directed at accomplishing the second aim, and special emphasis was placed on developing a technique for judging the relative significance of impacts that are expected to result from controversial proposals.

The approach to environmental resource management that is presented here is based on certain *a priori* premises derived largely from economic theory. From these premises the goal of resource allocation is defined, which in turn leads to the formulation of management objectives and evaluation criteria.

The goal of resource allocation is determined to be *to achieve the highest possible level of social well-being over a time period spanning multiple generations.* Resource management objectives are *to make resource use efficient, equitable and sustainable.* Given this goal and these objectives, one can derive the following evaluation criteria:

- The efficiency criterion - *an action is efficient if those who benefit could potentially compensate those who bear costs and still be better off, so that total benefits exceed total costs.*

- The equity criterion - *an action is equitable if it improves the distribution of welfare amongst different social groups comprising present-day society.*

- The sustainability criterion - *an action is sustainable if it improves the prospects that future generations will enjoy the same level of welfare now enjoyed by members of present-day society .*

The goal and objectives then provide the rationale for a management strategy, which emphasizes adoption of a national conservation policy, acceptance of certain principles on which to base legislative initiatives, and the development of appropriate administrative mechanisms to regulate and guide resource allocation decisions. An evaluation methodology is then formulated to serve the management strategy by providing a theoretically-sound and practical means of evaluating alternative proposals in terms of the evaluation criteria which have been derived from the goal and objectives.

This philosophical framework has been developed with regard to the situation in South Africa. Until recently (June 1989), there was no legal requirement for an Environmental Impact Assessment in South Africa - or any form of environmental evaluation procedure - to ensure that impacts to environmental services would be given appropriate consideration when making resource allocation decisions. In addition, there are few people with experience in applying methods and techniques associated with environmental assessment and evaluation, and few resources are available for conducting environmental investigations.

Accordingly, a special attempt has been made to develop an approach to evaluation and management which takes cognizance of this situation, and which provides simple, fast and cost-effective techniques for evaluating alternative resource allocation proposals. Although developed for South Africa, it is believed that the approach to resource management that is presented in this dissertation is applicable to any country, and is particularly appropriate for Third World countries.

The management strategy that is advocated here is intended primarily to provide the context within which an environmental evaluation methodology can be applied. A central feature of this strategy is to develop a national resource accounting system which is directed at ensuring that some minimum level of especially valued environmental services (*e.g.*, certain ecological processes and natural amenities) is maintained regardless of what local or regional development pressures arise. Another feature is the declaration of certain principles upon which legislation should be based, so that environmental considerations will always be taken into account before resource allocation decisions are made. Finally, the general approach and specific procedures associated with Integrated Environmental Management are considered an integral part of the proposed management strategy. This includes the adoption of iterative procedures for planning and assessment, the acceptance of screening and scoping procedures, and the routine use of environmental control plans.

The evaluation methodology offers a variety of formal and informal methods and techniques of evaluation. These include variations of conventional shadow-pricing techniques, and other methods for judging the significance of unpriced impacts; some of these methods and techniques have been modified to make them simpler and more practical to apply in the South African context.

Also included are a number of assessment and decision making techniques, as well as general guidelines for conducting an evaluation. Special attention, however, is given to the development and application of a formal method of evaluation designed to accomplish a number of tasks which are particularly important when resource allocation proposals are expected to be highly controversial.

The method that has been developed for evaluating especially controversial resource allocation proposals was the principal subject of research for this dissertation. Major challenges were to specify evaluation criteria, and to develop practical ways to apply these criteria, that would be acceptable to all parties involved in a conflict. Since resource disputes often revolve around the implications of alternative actions for future generations, and are usually focused on arguments about the relative significance of environmental impacts not valued in monetary terms, it was decided to

- modify the definition of the social welfare function in economic theory to explicitly address effects of proposed actions on future generations, and

- attempt to make utility numerical by devising a reliable means of judging, on an interval scale, the social significance of unpriced impacts.

After reviewing the literature, a set of procedures for undertaking a formal evaluation was developed and applied to two case studies. Several important lessons were learned from this experience, which led to the development of a new method that has been termed the Panel Evaluation Method. This method features three techniques which address the key tasks of a formal evaluation:

- The *Impact Identification Technique* is concerned with systematically <u>identifying and carefully defining the potentially significant impacts</u> of competing proposals.

- The *Significance Measurement Technique* is concerned with <u>judging the relative significance of these impacts</u>.

- The *Criteria Trade-off Technique* is concerned with <u>applying specified evaluation criteria</u> to identify the preferred alternative.

The object of applying a formal method of evaluation to a resource allocation proposal is to ensure that the evaluation process is comprehensive, systematic and explicit. In addition, if the evaluation is to defuse controversy, and satisfy those whose proposal is not selected, the evaluation should be seen to be unbiased, and the person or persons whose judgments are to be utilized should be respected by all concerned parties.

To ensure that the evaluation is acceptable, a group evaluation procedure involving neutral and esteemed persons was adopted. The well-known Delphi Method was selected as the model for this procedure. The Delphi Method, which was originally designed as a forecasting tool and is normally conducted through the post, was adapted to serve as an evaluation tool as well, and to be conducted in meeting situations in order to speed the forecasting and evaluation process.

The Panel Evaluation Method was applied to four case studies involving 12 panels in order to test and refine certain procedures and techniques. Evidence has been gathered which indicates that the method is capable of improving group judgments. The central focus was on testing a technique - called the Significance Measurement Technique - that has been designed to provide an estimate of the relative significance of impacts, both priced and unpriced. The technique substantially met three tests devised for determining whether group judgment was improved:

- movement toward consensus over several iterations of evaluation;
- a normal distribution of responses; and
- high correlations for weightings assigned by two or more similarly-constituted panels.

The major conclusions of the study are as follows.

- The management strategy and evaluation methodology to guide resource allocation decisions provide a theoretically-sound and practical approach to managing environmental resources.
- The Panel Evaluation Method provides a simple, thorough and cost-effective way to evaluate controversial resource allocation proposals
- The techniques for defining and evaluating impacts have been demonstrated to be capable of producing results that meet a reasonable standard of replicability at a reasonable cost and within a reasonable time.

TABLE OF CONTENTS

LIST OF BOXES, FIGURES AND TABLES

BOXES

FIGURES

TABLES

X

GLOSSARY OF TERMS

ADVISORS: Persons with some special expertise or interest pertaining to a proposal who assist in the impact identification and definition process.

ALTERNATIVE PROPOSAL: A possible course of action that would meet the same purpose and need of the original proposal (*cf.* proposal).

ANALYSIS: The act of studying and interpreting data, situations or concepts in order to attain an understanding of their meaning and relevance to some decision.

APPRAISAL: The act of evaluating data in order to make judgments needed to reach a decision.

ASSESSMENT: The process of collecting, organising, analyzing, interpreting and communicating data that are relevant to some decision (*cf.* evaluation).

BEQUEST MOTIVATION: The desire to leave one's natural or cultural heritage to descendents or future generations.

BIOPHYSICAL ENVIRONMENT: That part of the environment which did not originate with and is not dependent on human activities (e.g., biological, physical and chemical objects and processes).

CHAIN-REFERRAL TECHNIQUE: A procedure for identifying prospective panelists which involves asking nominated persons to nominate others in order to minimize bias and maximize participation in the panel selection process.

COMMON PROPERTY RESOURCE: A public good which is not owned by anyone, and which is vulnerable to being damaged or depleted by overuse (*cf.* pure public good).

COMPENSATION: Trade-offs between different parties, differently affected by specific proposals, to the mutual satisfaction of all concerned parties.

COMPREHENSIVE VALUATION PROCEDURE: A procedure for evaluating the efficiency of a proposal by scaling all impacts, whether priced or unpriced, in nonmonetary terms (*cf.* fractional contingency price valuation procedure).

CONSERVATION PROPOSAL: A proposal directed at ensuring the continued provision of existing resources over long time horizons in order to maintain or improve social well-being (*cf.* development proposal).

CONSUMER SURPLUS: The value a good has beyond that indicated by market price; the excess of the amount consumers are willing to pay for a good over the amount that is actually required in payment.

CONTINGENCY PRICE: The amount of money required to equalize the excess monetary benefit of one alternative over another.

CONTROVERSIAL RESOURCE ALLOCATION PROPOSAL: A proposal which is almost certain to give rise to a controversy which cannot be resolved through mitigation or compensation.

DECISION MAKER: The person(s) entrusted with the responsibility for allocating resources, or granting approval to a proposal.

DEVELOPMENT PROPOSAL: A proposal directed at increasing the flow of benefits from the existing resource base by reallocating resources and modifying the environment in order to improve social well-being (*cf.* conservation proposal).

DIRECT BENEFIT: An advantage one of two competing proposals has over another because the second proposal either (1) does not offer that benefit or (2) offers less of that benefit (*cf.* indirect benefit).

DYNAMIC OPPORTUNITY COST: A cost which grows (relative to other costs) over time.

ECONOMIC ACTION: Any action which improves social well-being by increasing net benefits to society, or by improving the distribution of benefits and costs between members of present-day society and/or between present and future generations.

ECONOMIC DEVELOPMENT: Change within an economy which increases real opportunities for satisfaction and therefore results in improved social well-being (*cf.* economic growth).

ECONOMIC GROWTH: The expansion of an economy through the increased output of goods and services which may or may not improve social well-being (*cf.* economic development).

ECONOMIC RATIONALITY: A form of rationality based on quantitative analysis and concerned with the search for optimality (*cf.* political rationality).

EFFICIENCY IMPROVEMENT: An increase in the level of benefits that can be obtained from resource allocation activity, or a decrease in the amount of resources needed to produce a given level of benefits.

EQUITY IMPROVEMENT: An improvement in the distribution of costs and benefits flowing from resource allocation activity among the different individuals or groups comprising society.

END IMPACT: An impact which affects social well-being and can be defined in a way that clearly distinguishes it from other such impacts (*cf.* intermediate impact).

ENVIRONMENT: The external circumstances, conditions, and objects that affect the existence and development of an individual, organism or group.

ENVIRONMENTAL ECONOMICS: That branch of economics which is concerned with ranking alternative environmental situations on a scale of better or worse.

ENVIRONMENTAL EVALUATION: The process of obtaining, organizing and weighing information on the consequences, or impacts, of alternatives (*cf.* Environmental Impact Assessment).

ENVIRONMENTAL IMPACT: An environmental change caused by some human act.

ENVIRONMENTAL IMPACT ASSESSMENT: (1) The administrative process by which the environmental impact of a proposed action is determined. (2) The investigation and documented analysis of any proposed action that could have adverse consequences for the human environment. (3) An activity designed to identify and predict the impact on human health and well-being of legislative proposals, policies, programmes, projects and operational procedures, and to interpret and communicate information about the impacts (*cf.* environmental evaluation).

ENVIRONMENTAL ISSUE: A concern felt by one or more parties about some existing or potential environmental impact.

ENVIRONMENTAL RESOURCES: Any resource found in the environment, whether man-made or natural.

ENVIRONMENTAL SERVICES: Public service functions (e.g., ecological processes and natural amenities) provided by nature (*cf.* environmental resources).

ENVIRONMENTAL SITUATION: A perceived condition or state which may embrace all aspects of the environment, physical and nonphysical, and which may include some projection of a future condition or state.

EVALUATION: The act of making value judgments or ascribing subjective values to data in order to determine their importance to some goal or their significance to some decision (*cf.* assessment).

EXTERNALITIES (EXTERNAL COSTS/BENEFITS): Costs or benefits which fall to some party not responsible for the action generating the costs or benefits.

FINAL PROPOSAL: A possible course of action which is worthy of a detailed evaluation (*cf.* preliminary proposal).

FIRST-ORDER IMPACTS: Impacts which are a direct result of some action (*cf.* higher-order impacts).

FORMAL EVALUATION: A systematic evaluation, performed by an individual or a group, in which there is some attempt to optimize, and subjective value judgments are clearly articulated and related, and/or expressed in numerical terms (*cf.* informal evaluation).

FRACTIONAL CONTINGENCY PRICE VALUATION PROCEDURE: A procedure for evaluating the efficiency of a proposal by calculating contingency prices for each unpriced impact (*cf.* comprehensive valuation procedure).

FRACTIONATION TECHNIQUE: A procedure for distinguishing the parts of a whole and measuring their relative value.

FREE GOOD: A good for which supply exceeds demand at a zero price (i.e., which does not involve an opportunity cost).

GOOD (noun): Any tangible or intangible thing which can provide utility.

GROUP (SOCIAL GROUP): A number of individuals related by some common factor who would be similarly affected by a proposal; an association of individuals who feel an affinity for one another.

HIGHER-ORDER IMPACTS: Impacts which arise from other impacts (*cf.* first-order impacts).

IMPACT: The outcome of an action, whether considered desirable or undesirable.

IMPACT REPORT: A document which provides an analysis of the impacts associated with a resource allocation proposal.

INDIRECT BENEFIT: An advantage one of two competing proposals has over another because a cost associated with the second proposal will be avoided (*cf.* direct benefit).

INFORMAL EVALUATION: A casual and personal evaluation in which there is no attempt to optimize, and subjective value judgments are not clearly articulated or systematically related, or expressed in numerical terms (*cf.* formal evaluation).

INTEGRATED ENVIRONMENTAL MANAGEMENT: A philosophy which prescribes a code of practice for ensuring that environmental considerations are fully integrated into all stages of the development process in order to achieve a desirable balance between conservation and development.

INTERGENERATIONAL/SUSTAINABILITY IMPROVEMENT: An increase in the likelihood that the flow of net benefits from resource use will be as great for future generations as it is for present generations.

INTERMEDIATE IMPACT: An impact which in itself may not directly affect social well-being or constitute a discrete impact, but which contributes or leads to some impact on social well-being which can be clearly distinguished from other such impacts (*cf.* end impact).

MARKET: That part of an economic system in which exchange takes place through the interaction of supply and demand, and which leads to the emergence of prices or values for those goods in which private property rights can be specified.

METHOD: A general type of procedure chosen to direct a scientific inquiry (*cf.* methodology, procedure, technique).

METHODOLOGY: (1) The process by which scientific inquiry is conducted, and theory is related to empirical research. (2) The logic of applying the scientific perspective to the study of events. (3) The description and analysis of methods (cf method).

MITIGATE: The implementation of practical measures to reduce adverse impacts or enhance beneficial impacts of an action.

MONETARY VALUE: A cost or benefit expressed in monetary terms, whether priced by the market or a shadow-pricing technique.

MONETIZABLE IMPACT: A cost or benefit which can be meaningfully expressed in monetary terms.

NATURAL RESOURCE: Any resource provided by the biophysical environment.

NONCONTROVERSIAL RESOURCE ALLOCATION PROPOSAL: A proposal which is not likely to give rise to controversy, or which is not likely to end in controversy; a proposal for which measures are available to mitigate impacts or compensate affected parties.

NONMONETARY IMPACT: An unpriced impact for which a shadow price may be obtained.

NONMONETIZABLE IMPACT: A cost or benefit which cannot be meaningfully valued in monetary terms.

NONPARTICIPANT DEMAND: The desire to maintain a resource because mere knowledge of its existence is a source of satisfaction.

NONRENEWABLE RESOURCE: A resource which is necessarily diminished by the act of consumption.

OPPORTUNITY COST: What must be foregone in order to obtain a desired end.

OPTION DEMAND: The desire to maintain one's options in order to take advantage of new knowledge or adjust to new circumstances which may arise.

OPTIMIZE: To find a solution to a problem which maximizes (or minimizes) some explicit and measurable criterion conditional on certain environmental assumptions and a specified time horizon (*cf.* satisfice).

PARETO CRITERION: A measure of efficiency which requires that at least one person be made better off by an action, while no one else is made worse off (*cf.* potential Pareto improvement).

PERSONAL EVALUATION STATEMENT: A written exposition which applies evaluation criteria to alternative proposals in a systematic and explicit way, and which results in a judgment as to which proposal should be selected.

PHILOSOPHY: A basic theory concerning a particular subject or sphere of activity; a critical study of fundamental beliefs and the grounds for them; a way of thinking and a guide to action.

POLITICAL RATIONALITY: A form of rationality based on qualitative analysis and concerned with finding satisfactory rather than optimal solutions to problems (*cf.* economic rationality).

POLLUTION: The residuals of human activity which adversely affect the next user of some environmental resource.

POTENTIAL PARETO IMPROVEMENT: A measure of efficiency based on a judgment as to whether an action would make at least one person better off even after (potentially) compensating those who would be made worse off (*cf.* Pareto criterion).

PRELIMINARY PROPOSAL: A possible course of action that is worthy of consideration (*cf.* final proposal).

PROJECT COORDINATOR: The person who is charged with coordinating an evaluation project.

PRESENT DISCOUNTED VALUE: The present value equivalent of a stream of future costs and benefits.

PROCEDURE: A series of prescribed steps for guiding or accomplishing a scientific inquiry (*cf.* method, technique).

PROPOSAL: A desired action (*cf.* alternative proposal).

PUBLIC SERVICE FUNCTIONS: Environmental services provided by the biophysical environment (e.g., ecological processes and natural amenities) which enhance social well-being.

(PURE) PUBLIC GOOD: A good which is not owned by anyone, and which is not depleted or damaged by consumption (*cf.* common property resource).

RELIABILITY: The degree to which a finding or result is capable of being replicated (*cf.* validity).

RENEWABLE RESOURCE: A resource which is capable of conferring benefits in perpetuity.

RESOURCE: Any good, service or environmental condition which has the potential to enhance social well-being.

RESOURCE ALLOCATION: The act of prescribing resource uses and otherwise managing resources to enhance social well-being.

RESOURCE DESTRUCTION: The unintentional depletion of a potentially renewable resource beyond some critical threshold necessary for its continued provision (*cf.* resource exhaustion).

RESOURCE EXHAUSTION: The intentional or calculated depletion of a resource (*cf.* resource destruction).

SATISFICE: To find a solution to a problem which satisfies some criterion at a level which is judged to be acceptable (*cf.* optimize).

SCOPING: A procedure for narrowing the scope of an assessment, and ensuring that the assessment remains focused on the truly significant issues or impacts.

SCOPING COMMITTEE: A group of informed and responsible persons who guide the assessment process to ensure that investigations are relevant and (as data are obtained) to suggest ways in which proposals might be improved.

SCORE/WEIGHT: The value given to an impact.

SCREENING: A procedure for determining the appropriate level of assessment.

SHADOW PRICE: The price which would be paid for a good if that good could be traded in the market.

SHADOW-PRICING TECHNIQUE: A procedure for estimating the value of an unpriced impact in monetary terms.

SHADOW PROJECT: A project following some development which is designed to restore some public service function to its original condition, or provide it in a new location.

SIGNIFICANT IMPACT: An impact which is regarded as important to social well-being; an impact that has crossed the threshold of significance.

SOCIAL IMPACT ASSESSMENT: An assessment that is specifically directed at identifying and analyzing impacts to social groups.

SOCIAL VALUE: A measure of value which encompasses the total effect of an outcome on society, including the extent to which benefits exceed costs, and consideration of the way costs and benefits are distributed (over groups comprising present-day society, as well as over multiple generations).

SOCIAL WELFARE FUNCTION: A statement of a society's objectives in which the level of social well-being is represented as a function of the way in which resources are allocated.

SOCIAL WELL-BEING: The state of welfare in society.

SOCIETY: The sum of all individuals, present and future, whose welfare could be affected by some resource allocation proposal.

SOCIOECONOMIC ENVIRONMENT: That part of the environment which has its origin or being in human activities (e.g., social, economic, cultural and political objects and processes).

STRATEGY: A general plan, philosophy, set of concepts or mode of action directed at achieving some end.

SUBJECTIVE: A condition relating to or arising from one's self or mind (as opposed to phenomena that are independent of the mind).

SUSTAINABILITY/INTERGENERATIONAL IMPROVEMENT: An increase in the likelihood that the flow of net benefits from resource use will be as great for future generations as it is for present generations.

SUSTAINED YIELD: The management of a resource to maintain a flow of benefits in perpetuity.

TECHNIQUE: A specific procedure to be applied in a scientific inquiry (*cf*. method, procedure).

THRESHOLD IMPACT: The first impact in a rank-ordered list of impacts which crosses the threshold of significance.

THRESHOLD OF SIGNIFICANCE: The point at which a value is judged to become sufficiently significant or important to be worthy of evaluation.

UNPRICED IMPACT: An impact which is not valued by the market, so that an evaluation of its utility requires a subjective value judgment; an impact which may or may not be amenable to shadow-pricing.

UTILITY: The satisfaction, pleasure or need-fulfillment derived from consuming some quantity of a good.

VALIDITY: The accuracy or truthfulness of a finding or result (*cf*. reliability).

VALUE: The total utility which is yielded by a good.

VALUE JUDGMENT: A statement of opinion or belief which is not capable of being falsified by comparison with fact.

WEIGHT/SCORE: The value given to an impact.

WELFARE: The state of an individual or society with respect to utility arising from utilization of the resource base.

CHAPTER 1

INTRODUCTION

BACKGROUND TO THE STUDY

The Initial Research Objective

In 1981 the Estuariné and Coastal Research Unit of the National Research Institute of Oceanology in Stellenbosch, South Africa initiated a two-year study into the problem of how to estimate the value of certain "*environmental services*"[1] found in the coastal zone. The study was wanted because scientists at the Estuarine and Coastal Research Unit felt that in reviewing applications for development in the coastal zone, authorities were giving inadequate consideration to many ecological processes and natural amenities of great value. The object of the study was to develop practical ways and means of measuring the value of "*unpriced impacts*" so that these could be more readily compared to monetary values, and better judgments could be made regarding the total effect of alternative resource allocation proposals on social well-being.

Although many methods and techniques of "*Environmental Impact Assessment*" have been developed to provide information on both "*monetizable*" and "*nonmonetizable*" impacts, few have attempted to price or otherwise calculate the relative value of all the outcomes - particularly incidental effects, or "*externalities*" - associated with a proposal. Since many of the external (or spillover) effects may be of great significance but are generally regarded as unmeasurable or incommensurable, it is difficult to judge whether the net social value of a proposal is positive.

A literature review revealed that there has been much research into this type of problem, and several different theories, methods and techniques were examined with the object of discovering a sound and practical approach to evaluation that would be appropriate to South Africa (Dohan, 1977; Krutilla and Fisher, 1975; Sinden and Worrell, 1979; Skutsch and Flowerdew, 1976). Among the measures investigated were attempts to quantify or express the value of scenic views (Arthur *et al.*, 1977; Linton, 1968; Litton and Burton, 1972), outdoor recreation (Brown and Nawas, 1973; Davidson *et al.*, 1966; Krutilla and Cicchetti, 1972), wilderness or natural environments (Blackie, 1980; Jones, *et al.*, 1978; Smith, 1977; Stankey, 1972), ecosystem functions (S.A. Department of Planning and the Environment, 1975; Greeson *et al.*, 1979; Hall, 1975; Hite and Laurent, 1971), and unique environments (Hamill, 1974; Leopold and Marchand, 1968).

In reviewing this literature, it was noted that most evaluation methods and techniques have a First World orientation. South Africa has many characteristics of a developing or Third World country (Berger and Godsell, 1988; Malan *et al.*, 1983; Page and Rabie, 1983; Sunter, 1987), and so these more sophisticated and costly approaches to evaluation were judged to be generally inappropriate. In addition, many of the approaches were designed to be applied to certain kinds of projects or to evaluate impacts to certain types of environments, and could not easily be transferred to other types of proposals or environments. In any case, the evidence in the literature suggests that no completely satisfactory approach to estimating the value of unpriced environmental services has yet been developed; in fact most Environmental Impact Assessments either do not attempt quantitative evaluations of the significance of impacts, or else use rather

1 The term "environmental services" is meant to include all goods, services and conditions contributing to man's well-being that are provided directly by nature. (For a full definition of this and other terms that are italicized and set in inverted commas, see the Glossary.)

unsatisfactory techniques to do so (Bisset, 1980; Duinker and Beanlands, 1986; Hollick, 1981a; Lee, 1982). Furthermore, it appears that attempts to develop environmental evaluation methodologies which emphasize formal approaches to evaluation are now uncommon (Beanlands *et al.*, 1984; Hollick, 1981a, 1986; Westman, 1985).

This situation can be attributed largely to the inherent difficulty in measuring subjective value judgments. But in the development of most formal evaluation methods and techniques, there have been some fundamental shortcomings. Foremost among these are:

- a lack of attention to first establishing a sound philosophical framework of acceptable principles and concepts within which one can then devise a rational strategy of resource management and a reliable research methodology for environmental evaluation;

- a failure to adequately test the replicability, flexibility and user acceptability of the evaluation procedures used; and

- a general unwillingness to provide guidance in making subjective value judgments concerning the desirability of various outcomes associated with specific environmental resource allocation proposals, particularly concerning the relative significance of environmental impacts, and trade-offs between the different objectives of resource management.

Although it may be true that it is impossible to perfectly measure the value of unpriced environmental services, it is also true that these services are being evaluated in some way whenever major resource allocation decisions are made; the question is whether it is possible to develop an approach to evaluation that would meet enough theoretical and practical objections to be regarded as useful. To be useful, an evaluation procedure would only have to represent an improvement over existing approaches to evaluation.

In order to improve the prospects that an approach to evaluation will be theoretically sound and practical to implement, it is necessary to examine commonly-held principles, precepts and tenets of the evaluation process within the decision making environment. The first challenge, therefore, was to develop a suitable philosophical framework or paradigm to guide the formulation of specific solutions to the evaluation problem.

A further examination of the literature indicated that the principles and concepts of decision theory (Bell *et al.*, 1977; Coyle, 1972; Edwards, 1967; Fardel and Gal, 1980; Kassouf, 1970; Keeney and Raiffa, 1976; Raiffa, 1968), economic theory (Baumol, 1972; Baumol and Oates, 1975, 1979; Beckerman, 1972, 1974; Boulding, 1970, 1971; Coase, 1972; Coombs *et al.*, 1970; Cottrell, 1978; Day, 1978; Dohan, 1977; Gregory, 1979; Herfindahl and Kneese, 1974; Kelso, 1977; Kiely-Brocato *et al.*, 1980; Kneese, 1977; Knetsch and Freeman, 1979; Krutilla, 1967, 1972, 1975, 1979; Lutz and Lux, 1979; Mishan, 1969, 1975, 1977, 1981; Okun, 1975; Seneca and Taussig, 1979) and measurement theory (Alchian, 1953; Baird and Noma, 1978; Green and Tull, 1978; Guilford, 1954; Stevens, 1951, 1957, 1975; Thurstone, 1954; Thurstone and Jones, 1959; Torgerson, 1958) offer a solid theoretical basis for resource evaluation and decision making. These disciplines have given rise to some particularly promising approaches to evaluation and decision making, and the initial research question was whether one or more of these approaches could be adapted to provide a satisfactory way to calculate the value or importance of unpriced impacts from developments in the South African coastal zone.

For example, Decision Analysis provides a logical approach to applying preferences to alternatives when there are multiple objectives and limited information for conducting an evaluation (Bakus *et al.*, 1982; Coyle, 1972; Edwards, 1967; Gardiner and Edwards, 1975; Miller and Ladd, 1984; Raiffa, 1968). Cost-benefit Analysis is a highly respected evaluation method that has been applied to a wide range of resource allocation problems (Abelson, 1979; Andrews, 1982; Bohm and Henry, 1979; Conopark and Reynolds, 1977; Kneese, 1984; Layard, 1972; Mishan, 1975; Pearce 1983; Sassone and Schaffer, 1978; Schramm, 1973). In recent years Cost-benefit Analysis has been strengthened by the development and widespread application of various "*shadow-pricing techniques*" (Batie and Shabman, 1982; Brookshire *et al*., 1980; Brookshire and Crocker, 1981; Brookshire *et al*., 1982; Brookshire *et al*.,1983; Cicchetti *et al*., 1972; Farber, 1988; Fischer, 1974; Flowerdew, 1972; Freeman, 1985; Gosselink *et al*., 1974; Gregory, 1986; Gupta and Foster, 1975; Menz and Mullen, 1981; Sinden, 1974; Sinden and Worrell, 1979; U.S. Council on Environmental Quality, 1979). In addition, certain measurement techniques which derive from psychology, decision science and other disciplines can be used to determine the relative value of unpriced effects for which shadow prices cannot be obtained, and to measure other subjective phenomena (Baird and Noma, 1978; Guilford, 1954; Stevens, 1951, 1957, 1975; Thurston and Jones, 1959; Torgerson, 1958). In particular, a method called "Delphi" seems uniquely suited to the problem of defining and evaluating the unpriced costs and benefits associated with resource allocation proposals (Bakus *et al*., 1982; Dalkey and Helmer, 1963; Dalkey *et al*., 1972; Hill and Fowles, 1975; Hogarth, 1978; Linstone and Turoff, 1975; Pill, 1971; Rohrbaugh, 1979; Salanick *et al*., 1971; Shafer and Moeller, 1981; Sutherland, 1975).

After preliminary investigations into the nature of resource conflict and decision making in the coastal zone, it was decided that the problem of evaluating the relative utility of any unpriced resource was essentially the same irrespective of the type of environment. Therefore when the initial two-year study for the Estuarine and Coastal Research Unit was completed (Stauth, 1982a, 1982b, 1982c), the subject of investigation was widened to encompass all resource allocation proposals, whether they involved environments that were coastal or inland, urban or rural, or social or natural.

The Need to Develop a Rational Philosophical Framework for Guiding the Evaluation Process

Although the central problem was still to find acceptable ways of measuring the relative value of impacts to unpriced environmental services, it was decided that this was inextricably linked to a larger problem of developing a practical research methodology of environmental evaluation, which would include, for example, both formal and informal methods for forecasting and defining impacts, and for applying and trading-off different evaluation criteria. Accordingly, the scope of the study was broadened to address this larger need.

But in order to develop a research methodology that would be appropriate to South Africa, it was necessary to first consider the circumstances in which it would be applied. For example, the theorist needs to be aware of any practical constraints imposed by existing policies, legislation, and administrative structures; he also needs to know the extent of the data base, as well as the manpower, expertise and other resources available for evaluation activities. Although decision makers in South Africa have relatively little experience with environmental evaluation, and few resources are currently available for this purpose, the country is presently going through profound changes, and there are several indications that new policies, legislation and administrative structures will soon be in place.

It seemed appropriate, therefore, to take cognizance of these new developments, and devise a recommended "*strategy*" of resource management consisting of policies and administrative procedures which would appear to be both viable and desirable under a wide range of circumstances; this in turn would provide the context for the development of a research "*methodology*" of evaluation.[2] As part of this study, therefore, a philosophical framework was first developed to provide general guidelines for making better resource allocation decisions, and the management strategy and evaluation methodology are part of that framework.

In order to develop this framework, it was felt necessary to explicitly state and analyze the rationale which underpins resource allocation proposals. Thus, to guide the development of a recommended management strategy and evaluation methodology, some judgments had to be

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2 Although developed for South Africa, both the resource allocation strategy and the environmental evaluation methodology appear to be appropriate for other countries as well (both First and Third world).

made pertaining to certain fundamental questions, such as: "What is the goal of resource allocation?" These judgments were based primarily on principles and concepts discovered in the literature on economics (Baumol and Oates, 1979; Boulding, 1971; Cottrell, 1978; Dohan, 1977; Dorfman and Dorfman, 1972; Fisher and Peterson, 1976; Freeman *et al.*, 1973; Gregory, 1979; Herfindahl and Kneese, 1974; Kneese, 1977; Lipsey, 1979; Lutz and Lux, 1979; Mishan, 1977, 1981; Page, 1977; Samuelson, 1973; Seneca and Taussig, 1979). Both the management strategy and the evaluation methodology are derived from explicitly stated premises, goal, objectives and criteria.

The major challenges in developing a general environmental evaluation methodology are to define, to the satisfaction of decision makers and the general population:

- the ultimate goal of resource allocation;
- the specific criteria by which proposals should be judged;
- general policies and procedures to guide or constrain decision makers; and
- specific methods and procedures for applying evaluation criteria to competing resource allocation proposals.

The goal, criteria, policies, and methods must be based on a firm theoretical foundation, and then must be demonstrated to be reasonable in practice, if they are to achieve wide acceptance as a basis for making resource allocation decisions. Evaluation procedures must also be comprehensive and flexible enough to be applicable to any kind of proposal, on any scale. A special challenge is to develop an acceptable procedure for making explicit evaluations of the relative significance of forecast outcomes. Finally, a systematic procedure is needed for comparing alternatives in terms of the selected criteria (or different objectives), making trade-offs between these criteria/objectives, and then selecting the preferred alternative.

On initial inspection these challenges may seem impossible to accomplish. Is it possible to obtain general agreement as to the goal of environmental resource allocation? If so, can we agree on specific objectives, and a comprehensive set of criteria for measuring whether a given proposal will carry us toward or away from that goal? What "measuring rod" can be applied to judgments as to the significance of outcomes, and can the same measuring rod be applied to all outcomes? Finally, what policies and decision rules should be adopted so that, for any two proposals, the different implications in terms of the agreed objectives or selected criteria can be compared and rational trade-offs made?

As difficult as these tasks may appear, resource management necessarily entails addressing them in some way. Every resource allocation decision involves at least an implicit evaluation of alternatives in terms of some goal (often ill-defined) and some criteria (perhaps unstated) relevant to that goal, and in accordance with some policy or administrative procedure; and every resource allocation decision also involves some kind of scaling procedure (usually informal and even unconscious), or "weighing up" of the consequences of specific actions; and then finally some kind of trade-off procedure (usually very casual and perfunctory) is applied to select the preferred action. Since these tasks must be accomplished, consciously or unconsciously, it seems desirable to formalize their accomplishment as much as is possible by clearly identifying what is being done and why. This should lead to clearer, better decisions, and greater understanding and acceptance of these decisions.

To sum up then, the first task in developing a resource management strategy and evaluation methodology is to define an acceptable goal for resource allocation activity, and to devise a set of criteria and policies that are relevant to the goal and that provide a clear guide to action. Then it is necessary to develop a set of evaluation procedures for applying the criteria to specific proposals. Of special interest are procedures for evaluating proposals which are especially controversial.

The Need to Develop a Formal Method of Evaluation for Especially Controversial Resource Proposals

In the course of developing a research methodology for improving resource allocation decisions in South Africa, it was determined that there are two broad categories of resource allocation proposals.

- The first category consists of proposals which may or may not involve significant impacts, but which in any case are not particularly controversial or complex, and therefore are not expected to be characterised by serious conflict or present serious problems of evaluation. For this category of proposal conventional methods of analysis, and "*informal evaluations*" by analysts and decision makers, will generally be accepted by all concerned parties.

- The second category consists of proposals with potentially significant impacts which are extremely controversial and difficult to evaluate. Proposals of this type tend to polarize communities, leading to considerable conflict between opposing interest groups, and heated debate over the relative importance of various issues. For this category of proposal there is a need for a "*formal evaluation*" procedure which all parties will respect, and which can therefore also serve as a conflict resolution procedure.

The topic that was ultimately selected for this dissertation was to develop a philosophy of evaluation and management for improving resource allocation decisions which would feature a formal method for evaluating especially complex and controversial resource allocation proposals in South Africa.

OBJECTIVES OF THE STUDY

This study had three principal objectives:

- The first objective was to develop a general framework of evaluation and management that would constitute a practical and reliable guide to action, and thus provide an effective means for improving resource allocation decisions in the South African context.

- The second objective was to devise, within this framework, a specific method for evaluating those resource allocation proposals which are highly controversial (because they involve resources of special importance, and will result in outcomes that are especially significant to one or more groups, but are difficult to evaluate) and which therefore require a formal evaluation.

- The third objective was to apply the special method of formal evaluation in a number of case studies to determine whether the method is capable of producing replicable results (and meeting other tests for assessing its usefulness and acceptability), and whether the method is applicable to the full range of resource allocation problems in South Africa.

SCOPE OF THE STUDY AND FOCUS OF THE DISSERTATION

As indicated above, the scope of this study first shifted from a concern with the problem of determining values for unpriced environmental services in the coastal zone, to the much broader concern of developing a philosophy of resource management, a research methodology for environmental evaluation, and a formal method of evaluation for South Africa. As research progressed, the focus of the study again narrowed down to the problem of developing and testing techniques associated with the formal method for evaluating controversial resource allocation proposals.

In order to develop a rational approach to environmental evaluation, and particularly to evaluating controversial resource allocation proposals, it was necessary to clearly formulate the general goal and objectives of resource allocation, as well as the criteria that should be applied to competing proposals. In addition, there was a need to identify any policy constraints on resource allocation, and suggest suitable administrative procedures for processing resource allocation proposals. Once this framework had been developed, then it was possible to design a method and appropriate techniques for accomplishing the central tasks of "*assessment*" and "*evaluation*".

The following steps were involved in developing the resource management strategy, the environmental evaluation methodology, and the method for evaluating especially controversial resource allocation proposals (see Figure 1.1):

- identifying *a priori* premises from which the goal of resource allocation could be determined;
- formulating a clear and acceptable goal statement to guide resource allocation activities;
- defining resource allocation objectives, and the evaluation criteria that can be derived from these objectives;
- prescribing management policies that are based on the goal, objectives and criteria;
- proposing enabling legislation, as well as practical administrative procedures for processing resource allocation proposals; and
- developing an evaluation methodology which consists of a range of appropriate assessment and evaluation procedures to guide the decision making process.

While the general scope of the study was very broad, most of the research effort was on developing the formal method for evaluating especially complex, contentious or otherwise difficult and socially significant resource allocation proposals. Therefore, the focus of the dissertation is on developing and testing the formal evaluation method, while other aspects of the management strategy and evaluation methodology are less fully developed.

CONSTRAINTS ON THE STUDY

The multidisciplinary nature of the study meant that it was necessary to investigate a number of topics and fields of thought for which there is an extensive literature. It was obviously not possible to review the entire literature, or to become equally proficient in all areas.

For various personal reasons this study spanned a period of nearly nine years (from early 1981 until late 1989) and therefore the initial literature review was undertaken many years before the study was completed. Earlier sources are more frequently cited because they were instrumental in formulating the study design and inspiring ideas that led to the development and testing of various aspects of the strategy, methodology and method. In addition, toward the end of the study it became increasingly difficult to obtain information from overseas sources due to the growing economic and cultural boycott of South Africa.

Another major constraint on the study was the fact that research funds were limited, and there were few opportunities to apply evaluation techniques except in studies that were commissioned to accomplish other objectives. This meant that there were serious limitations on the amount of experimentation that could be done; this was a particular handicap in determining what factors are of importance in achieving replicable results from a particular technique. It was decided that rather than compare several techniques under different conditions in order to discover which technique is better under which conditions, the research strategy would be to study a promising evaluation technique in depth in order to delineate its region of applicability and more thoroughly assess its general efficacy.

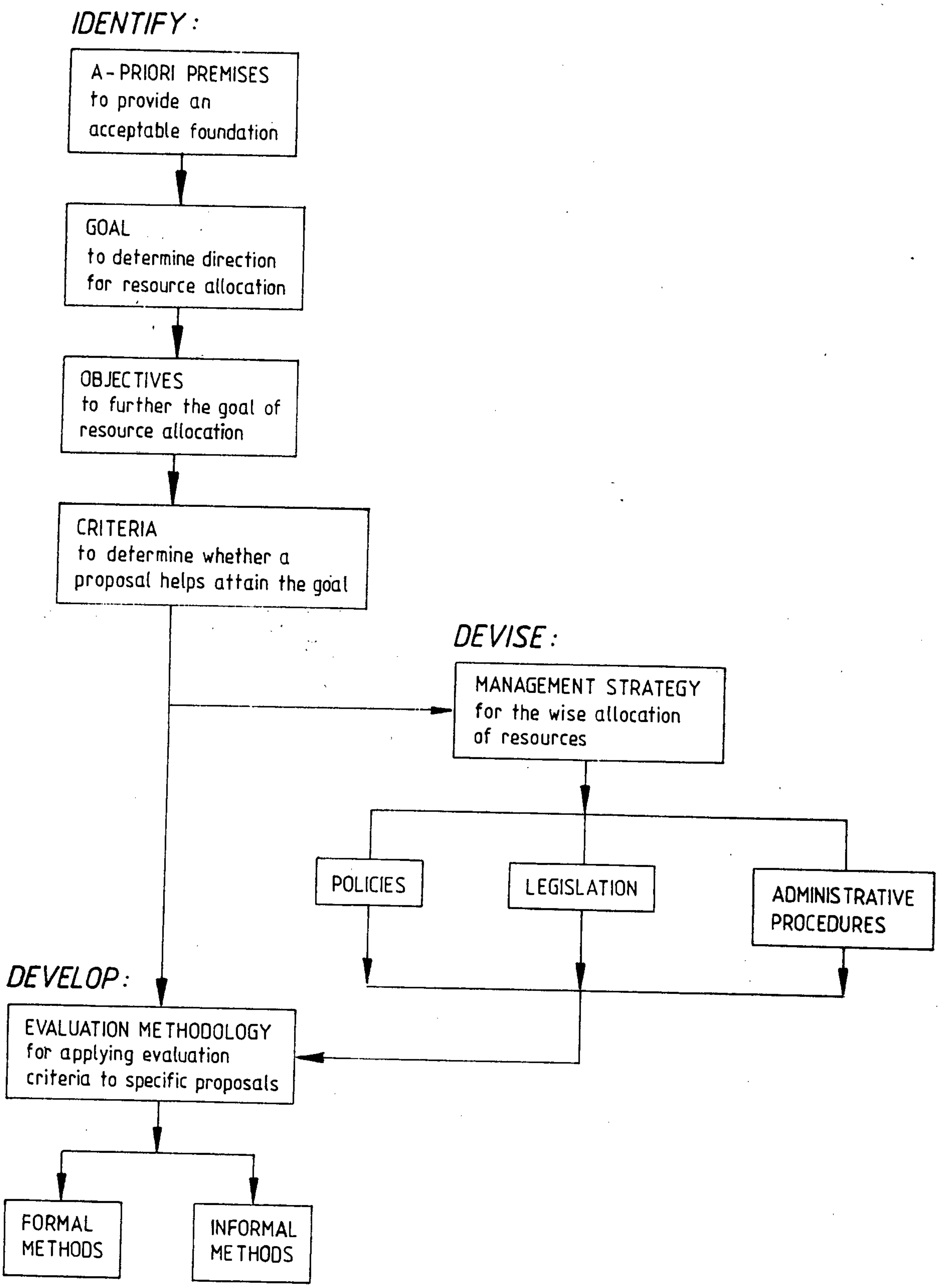

FIGURE 1.1 **Formulating a Philosophical Framework for Guiding Resource Allocation Decisions**

PLAN OF DEVELOPMENT

This dissertation consists of seven chapters. Following is a brief description of each of the remaining chapters.

In Chapter 2, the central problem that is addressed by this dissertation is defined. This is the problem of how to decide which of two or more resource allocation proposals should be selected, particularly when the alternatives are mutually-exclusive and highly controversial.

In analyzing this problem, two different approaches to environmental evaluation are suggested - "formal" and "informal" - depending on the degree of controversy associated with a proposal. A distinction is made between "Environmental Impact Assessment" and "environmental evaluation", and the special difficulties relating to the development of a formal method of environmental evaluation are discussed.

In Chapter 3, the research problems which have been identified are analyzed in terms of certain theoretical concepts found in a general review of the literature. Decision theory, economic theory and measurement theory provide the major principles and concepts which are relevant to the development of an evaluation methodology.

Special attention is given to examining those concepts which are particularly germane to the central problem of developing a formal method of evaluation for controversial resource allocation proposals. Several promising methods and techniques for accomplishing specific tasks which are related to the central research problem are identified, and these are briefly described. These include Delphi, Nominal Group Technique, and Cost-benefit Analysis, as well as various shadow-pricing techniques and methods for constructing ratio scales for nonmetric stimuli.

Chapter 4 is concerned with bringing various theoretical concepts together to form a unified basis for the development of a rational approach to environmental resource management. These concepts are first used to define the goal of resource allocation and the evaluation criteria that should be applied to resource allocation proposals. Then a recommended resource management strategy is described to provide the general context for applying an environmental evaluation methodology.

Attention then turns to the methodology itself, and the task of developing procedures for evaluating specific resource allocation proposals. The principal methodological concern is to develop a set of special procedures for evaluating those resource allocation proposals which are considered particularly problematic and controversial.

Certain procedures are then developed and applied to two case studies. The results of these case studies are analyzed, and the strengths and weaknesses of the procedures used are discussed to provide direction for developing a formal method of evaluation.

In Chapter 5, a method for conducting formal evaluations of controversial resource allocation proposals is presented, along with a case study which illustrates how the various procedures which comprise the method are to be applied. The method - called the Panel Evaluation Method - has been designed to provide a satisfactory way of accomplishing the three major objectives associated with evaluating controversial resource allocation proposals:

- to identify and define all impacts of possible concern;
- to determine the relative significance of these impacts; and
- to judge which of the alternative proposals best satisfies the specified evaluation criteria.

Three techniques have been devised for accomplishing these objectives, and the procedures involved in applying each of the techniques are described in general terms. Particular attention is given to the technique for judging the relative significance of impacts: the Significance Measurement Technique. Emphasis was given to developing and testing this technique because the initial research objective was to find a suitable way to determine the value of unpriced environmental services. In addition, it was felt that if this could be satisfactorily accomplished, such a technique would serve to link and strengthen Environmental Impact Assessment and Cost-benefit Analysis, and so constitute a substantial contribution to knowledge.

After a general description of the Panel Evaluation Method, there is a detailed description of how the method can be used to accomplish nine tasks that are identified as being of special importance in a formal evaluation. After the description of each task, the results of a case study are presented to illustrate how the relevant procedures for accomplishing that task can be applied.

Because of the fundamental difficulties involved in judging the relative significance of impacts, and the central importance of this task, the chapter concludes with an assessment of the effectiveness of the Significance Measurement Technique, and a discussion of different possible applications of the technique.

In Chapter 6, an analysis of three additional case studies is presented. These studies were undertaken to further assess the usefulness of the Panel Evaluation Method and the reliability of its techniques. The focus of these investigations was on the Significance Measurement Technique, and in this case replicability was assessed by calculating product-moment correlation coefficients for significance measurements accomplished by different panels.

A special effort was made to apply the method to resource allocation proposals which differed in fundamental ways from those evaluated previously; this was done in order to demonstrate the general applicability of the method and the extent to which specific procedures could be adapted to suit particular circumstances.

In some instances, other techniques were used in conjunction with those of the Panel Evaluation Method to demonstrate the general flexibility and adaptability of the method. There was also an attempt to develop improved variations of the principal procedures comprising the method: ways were found to speed the impact identification and definition process, and two fundamentally different ways of evaluating the relative efficiency of proposals were developed and applied.

Finally, there was concern as to whether two panels might come to very different conclusions about the identity or significance of impacts, or whether they might be influenced in some way by the "*project coordinator*" or some other factor. Therefore a programme of testing was developed which involved appointing different panels and project coordinators to apply the same procedures to the same evaluation problem so that some assessment could be made of the extent to which key judgments were replicable.

In Chapter 7, the major findings are discussed and the principal conclusions of the study are presented. The proposed management strategy and evaluation methodology are judged to provide a theoretically-sound and practical approach to managing environmental resources, and the Panel Evaluation Method is judged to provide a reliable and cost-effective way to evaluate controversial resource allocation proposals.

CHAPTER 2

THE PROBLEM OF EVALUATING RESOURCE ALLOCATION PROPOSALS

OVERVIEW

This chapter begins by exploring the nature and context of the resource decision making problem, and identifying two major approaches that can be taken to evaluating resource allocation proposals. Key terms are defined, and concepts important to the development of an environmental evaluation methodology are discussed. These include "controversial" and "noncontroversial" proposals, "formal" and "informal" evaluations, and "Environmental Impact Assessment" and "environmental evaluation".

The chapter is centrally concerned with the problem of how to accomplish a satisfactory evaluation of those resource allocation proposals which are extremely complex and controversial. As defined in this dissertation, "*controversial resource allocation proposals*" typically involve serious disputes between two or more groups over inherently incompatible uses of a set of resources, so that there is little prospect for a compromise solution. In addition, the implications of the decision are often of potentially great significance to society as a whole, and it is usually not obvious which proposal would be in the best long-term interests of society.

The chapter concludes with a brief description of the general requirements of an environmental evaluation methodology, and the nature of the principal challenges associated with evaluating especially controversial resource allocation proposals.

THE NATURE OF RESOURCE ALLOCATION PROPOSALS

The Potential for Controversy

The term "*resource allocation*" refers to the process of utilizing a set of resources in a particular way to achieve some objective. A "*resource*" is anything that may be regarded as beneficial or useful by any group, and therefore includes "*public service functions*" (such as ecological processes and natural amenities). Resource allocation proposals often have significant implications for environmental services, and these potential "*environmental impacts*" generally give rise to some level of controversy.

Resource allocation proposals often involve a complex mixture of resources. A single proposal, for example, can require the extraction, alteration or destruction of such resources as minerals, soil, water, wildlife, indigenous vegetation, historic buildings, clean air, peace and quiet, scenic vistas and recreational space. Some of these resources are especially valued by certain groups (e.g., industrialists, farmers, conservationists, or recreationists) who may wish these resources to be employed in some alternative use. The question is, how does the "*decision maker*" (the person or organization vested with management responsibility) determine what would constitute the best use of these resources?

When a new development is proposed that would impact an area that is regarded as sensitive because of its special values, or that would have some other effect on the "*environment*" that could be regarded as a "*significant impact*", there is a potential conflict that involves three groups: those who would gain from the proposal, those who would lose, and those who have jurisdictional responsibilities relating to the proposal. While it is obviously in the interests of each of the contending parties to "win" the conflict, each also wishes to avoid costly battles and an unjust defeat. At the same time, the responsible authorities normally wish to minimize involvement in controversial issues, and avoid antagonizing or alienating any interest groups. All three groups thus want to minimize the conflict, and there is incentive to adopt some mutually-acceptable procedure for evaluating the options and bringing about a just and equitable solution. Therefore, all groups have a substantial interest in finding a way to ensure that a fair hearing, rational debate, and just decision will be provided in a timely and cost-effective manner.

There are several difficulties inherent in formulating resource allocation proposals, and ensuring that the best alternatives are identified and given proper consideration. Although there is usually some person (or small group) with ultimate responsibility for the final decision as to how to allocate a particular set of resources, resource decision making almost never consists of a single decision, but usually requires a large number of decisions to be made in a certain sequence, and very often involves a large number of persons interacting at different levels. A major difficulty in resource decision making is coordinating the interrelations between these individuals so that the most promising resource allocation proposals are generated and presented to the ultimate decision maker.

Once alternatives are formulated - within the framework of any legal, political, or administrative constraints that may exist - there is the difficulty of developing and applying a procedural mechanism for forecasting and evaluating the outcomes associated with each alternative in a way that is clear and acceptable to all concerned parties. This is a very difficult problem because the future is clouded with uncertainty, and because value preferences are not easy to measure or express. In addition, there are generally limited resources available for investigations and often a lack of expertise for conducting needed assessments of the alternatives. Cost-effective administrative procedures are therefore needed to ensure that the appropriate level of effort is expended on assessments, and that the affected publics have an opportunity to be heard.

Another general difficulty is that the final evaluation and decision is often not subject to public scrutiny, so that there are often misconceptions about the reasons for the decision that is taken, and the controversy flares up instead of being resolved. It is therefore desirable to adopt standard procedures for making the evaluation and decision making process clear and explicit. Finally, after a proposal has been approved, there is a need to apply reliable and efficient procedures to regulate and monitor approved actions so that controversy is not renewed due to poor mitigation during implementation, or to unforseen impacts which may arise.

Distinguishing Between Controversial and Noncontroversial Proposals

Almost all resource allocation proposals generate some degree of controversy because there is usually one or more groups that will be adversely affected. A group may, for example, be subjected to pollution impacts (such as smoke and odours from a factory), or lose the use of some "*common property resource*" that it now enjoys (such as a wilderness area or a neighbourhood rich in buildings from another era). In fact, resource allocation disputes arise because impacts to "*environmental resources*", whether part of the "*biophysical environment*" or the "*socioeconomic environment*", are perceived to be especially significant or fall with different weight on different groups comprising society.

Noncontroversial Proposals

Very often, however, the issues associated with a resource allocation proposal do not generate much interest or concern, and so the controversy is muted; in still other cases, the differences between competing proposals can be largely reconciled so that controversy is defused. In this dissertation, both of these types of cases will be referred to as "*noncontroversial resource allocation proposals*". In such cases the decision maker is faced with a fairly straightforward situation in which most or all of the following conditions obtain.

- There is a real problem and a clear need for some action.

- The "*proposal*" is the only "realistic" solution to the problem (i.e., there are no fundamentally different "*alternative proposals*" for meeting this need which are considered viable or desirable).

- There are ways to avoid, or reduce the severity of, adverse impacts to levels that would be acceptable to the major social groups that would be affected, or to adequately compensate affected parties.

- There are no major competing proposals for utilizing the area or the resources that would be involved.

For example, a community may need to supplement its water supply, and the only solution that is technically and economically viable is to build a water storage scheme in a nearby catchment; although this action would result in adverse environmental impacts and foreclose alternative uses of certain resources in the catchment (e.g., farming activities or housing developments in the basin, white-water rafting or other river-based recreation), measures can be taken to satisfactorily "*mitigate*" impacts or "*compensate*" those who would bear impacts, and there are no strongly competing demands on the area or its resources (e.g., forestry or conservation needs).

Controversial Proposals

But occasionally a resource allocation proposal will trigger a strong reaction amongst one or more publics, and generate highly emotional debate on several major "*environmental issues*". This debate can then lead to a situation of extreme conflict and polarization between the principal parties, and the decision maker often comes under great pressure and criticism from these contending groups. In such cases (which in this dissertation will be referred to as controversial resource allocation proposals), the decision maker is faced with a far more complex and difficult situation, characterized by the following conditions.

- There are two or more proposals which involve fundamentally different uses of the same set of resources, so that the proposals must be seen as inherently incompatible and mutually exclusive.

- There are two or more groups with different interests in the proposals, and members of these groups feel strongly that their well-being would be seriously diminished by one of the proposals.

- There is no way to measure or evaluate, in a purely objective manner, the relative merits of the claims and arguments made by the contending parties.

- There is no way to mitigate impacts, or compensate those who would bear impacts, that would satisfy the aggrieved parties.

The most familiar type of controversial resource allocation proposal is the "*development proposal*" which would damage or destroy resources which are considered irreproducible and irreplaceable. There is invariably a competing "*conservation proposal*", and in these situations there is often little room for compromise. An example is the Palmiet River controversy, in which a water storage scheme would inundate a sizable portion of the best preserved fynbos reserve left in South Africa (see Case Study 4 in Chapter 6). Many conservationists feel strongly that this reserve should not be violated, and that water users should pay the much higher monetary cost of desalinated water so that this valuable asset will not be lost. But many water users do not value the fynbos, and do not wish to pay the substantially higher water bills that would result if water needed to meet projected demand were obtained from unconventional sources.

In such a situation, the initial emphasis should still be on finding some compromise solution, or acceptable offer of compensation (such as a "*shadow project*" that would rehabilitate other such areas). But if it is not possible to find a suitable compromise, then an evaluation of the leading alternatives (preferably alternatives selected by the respective proponents) should be undertaken. This would involve a systematic assessment and "*analysis*" of the data, followed by an explicit "*appraisal*" of the social welfare implications of the proposal and the principal alternatives to determine what course of action would be in the overall best interests of society. The evaluation procedure adopted should be open and acceptable to all concerned parties.

THE NEED FOR A PRACTICAL AND COMPREHENSIVE METHODOLOGICAL FRAMEWORK TO GUIDE ENVIRONMENTAL EVALUATIONS

Any procedure for evaluating resource allocation proposals (whether controversial or noncontroversial) should be directed at answering the following questions:

- What is the nature of the development and the area that will be affected?
- What will be gained and what will be lost if the development is approved?
- Who will be the gainers and who will be the losers?
- What will be the significance of these gains and losses to specific groups?
- Are there ways of mitigating losses or compensating losers, and are the costs of mitigation/compensation reasonable?
- For society as a whole, will the gains outweigh the losses?
- What are the implications for future generations?

These are complex questions, and there is generally limited time and money available to provide the answers. If the proposal is not especially controversial, then an <u>informal evaluation</u> may suffice; but if the situation is particularly controversial, and involves resources of some importance, then a <u>formal evaluation</u> should be conducted.

Formal and Informal Evaluations

Both formal and informal evaluation procedures are directed at essentially the same object: to forecast the consequences of an action, determine the relative significance of these consequences, and judge the ultimate social worth of the action. But, as defined in this dissertation, these two general approaches to evaluation differ in important ways.

The object of an informal evaluation is to "*satisfice*", or find a satisfactory solution to a resource allocation problem. An informal evaluation is characterized by the application of individual judgments in a relatively *ad hoc* or unsystematic manner; in addition, the principal judgments which give rise to a decision or position are usually not clearly formulated, so that underlying attitudes, opinions and values tend to be obscured in any pronouncements on the subject of the evaluation.

By contrast, the object of a formal evaluation is to "*optimize*", or attempt to find the "best" solution to a resource allocation problem. A formal evaluation is characterized by individual or group judgments which are applied in a rigidly-defined and systematic manner; in addition, the process requires that subjective value judgments are made explicit. The basis for the judgments should also be made clearly apparent.

Because the basic orientation differs, formal and informal evaluations utilize very different procedures for approaching resource allocation problems. The most fundamental difference is that informal evaluations rely largely on qualitative methods of valuation whereas formal evaluations rely more on quantitative methods. In formal evaluations, therefore, there is an emphasis on expressing value judgments in numerical terms.

Environmental Impact Assessment and Environmental Evaluation

Environmental Impact Assessments are concerned with providing data which can be used to undertake either a formal or an informal evaluation.[1] Usually, an Environmental Impact Assessment is directed at gathering fact and opinion to assist decision makers in undertaking an informal evaluation of the options (Bisset, 1987; Burton *et al.*, 1983; Munn, 1975). If the proposal is regarded as being relatively noncontroversial, then an Environmental Impact Assessment and informal evaluation will suffice.

Although Environmental Impact Assessment sometimes includes explicit evaluations (Clark, 1984; Bisset, 1987; Shopley and Fuggle, 1984) - and indeed some level of evaluation is obviously always implied - as defined in this dissertation there is an important difference in the requirements of an "*environmental evaluation*" and those of an Environmental Impact Assessment. Environmental evaluation is defined as the process of "obtaining, organizing and weighing information on the consequences, or impacts, of alternatives" (McAllister, 1980:3). The key word in this definition is "weighing", which implies determining the value or relative significance of impacts.

Environmental Impact Assessment does not always involve a procedure for comparing the significance of the impacts, or judging the social value of a proposal, in either qualitative or quantitative terms. Bisset (1987:8-9) says that Environmental Impact Assessment methods are "structured mechanisms for the identification, collection and organization of environmental impact data". Munn (1975:23) defines Environmental Impact Assessment as "an activity designed to identify and predict the impact on man's health and well-being of legislative proposals, policies, programmes, projects and operational procedures, and to interpret and communicate information about the impacts". In these definitions there is no requirement for the impacts to be weighed or explicitly evaluated. An Environmental Impact Assessment document obviously provides (and in fact is designed to provide) information that can be used to evaluate alternatives, and will almost always contain implicit (and sometimes explicit) value judgments; but very often, Environmental Impact Assessments do not provide a comprehensive, systematic and numerical evaluation - *i.e.*, a formal evaluation - of the proposals under consideration.

All evaluations involve some kind of "weighing up" of values and trading-off of criteria, but a formal evaluation is accomplished with a set of clearly-defined procedures designed to make the evaluation process logical and transparent, while an informal evaluation is done less systematically and openly. A formal evaluation thus aims at accomplishing a thorough and explicit application of specified evaluation criteria using procedures that are acceptable to all concerned parties. The Environmental Impact Assessment always plays a vitally important role in informing the evaluation process, but when proposals are highly controversial there should - in addition to an Environmental Impact Assessment - always be a formal evaluation of the principal alternatives under consideration.

Several methods and techniques of Environmental Impact Assessment do incorporate formal evaluation procedures - e.g., the Environmental Evaluation System (Dee *et al.*, 1973) - but these have generally been designed for special types of resource allocation proposals (and so lack general applicability), and/or do not utilize procedures which adequately address all of the tasks necessary to accomplish a satisfactory evaluation when proposals are controversial. Specifically, many evaluation procedures associated with Environmental Impact Assessment tend not to provide a thorough and credible approach to accomplishing all of the following tasks:

1 Appendix A presents a brief history of the development of Environmental Impact Assessment and environmental evaluation.

- precisely defining impacts in terms of social costs and benefits;
- evaluating the relative significance of these impacts; and
- applying and trading-off explicit evaluation criteria.

In addition, formal evaluation procedures that are associated with Environmental Impact Assessment methods are often applied by persons whose judgments many not be respected or accepted by the principal concerned parties, or they involve algorithms which may be regarded with suspicion. Finally, most of the well-known environmental evaluation procedures were developed for application in the First World, while in the Third World the lack of skills and money may make them seem too cumbersome, inflexible and costly.

The Need to Develop Both Formal and Informal Approaches to Evaluating Resource Allocation Proposals

To sum up so far, two broad categories of resource allocation proposals can be defined:

- those which appear to be of little interest or are characterised by issues for which compromise solutions seem to be possible; and
- those which have the potential of becoming highly contentious and disruptive issues in society.

It is suggested that for essentially noncontroversial proposals, all that is really required is to develop systematic and cost-effective procedures to guide informal evaluations of alternative resource allocation proposals to improve the prospects that superior (and at least satisfactory) proposals will be identified and implemented. These low-cost, informal evaluations would be conducted at all stages of the resource development process, such as the conceptualization and planning stages, the assessment and decision making stages, and the implementation, monitoring and decommissioning stages. The object would be to provide a set of simple and clear procedures to ensure that environmental considerations are being taken into account throughout the development process, and weighed or evaluated against other planning, decision and management criteria.

For especially controversial proposals, however, there is in addition a need to develop a formal method of evaluation, acceptable to all concerned parties, for undertaking an explicit appraisal of the social value of the most promising proposals identified in the planning stage. This formal evaluation would constitute a special input to the decision stage, and although it would be associated with the assessment stage, it should be regarded as a process which is distinct from the conventional Environmental Impact Assessment process. To be acceptable, this formal evaluation method must be perceived as being relevant, trustworthy and practical to apply. This means that such a method should be capable of providing an evaluation that is comprehensive, explicit, unbiased, systematic, reliable and cost-effective. In addition, particularly for Third World countries like South Africa, it should also be capable of dealing with situations in which there is a lack of objective, verifiable data and a shortage of expertise for conducting investigations and evaluations.[2]

The Challenge of Developing a Formal Evaluation Procedure

Two of the most challenging tasks of a formal evaluation are to accurately forecast the consequences of the proposed action (as well as those of alternatives to the proposed action), and then clearly and unequivocally evaluate the relative significance of these consequences. Several attempts have been made to develop quantitative methods and techniques for accomplishing formal evaluations within Environmental Impact Assessment, but none have

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2 Appendix B presents a detailed discussion of the requirements of an environmental evaluation methodology that would be comprised of both formal and informal evaluation procedures.

achieved widespread acceptance (Hollick, 1986:163). It is unfortunate, in view of the great number of resource allocation proposals which are highly controversial, that there has not been more success in developing a formal method of evaluation that has general applicability and widespread appeal. But theoreticians face several formidable difficulties which may seem impossible to overcome:

- to develop a method that is capable of being applied to any resource allocation problem under a wide range of practical constraints (e.g., limited money, time and manpower);
- to provide sound guidance in how to express subjective value judgments in numerical terms;
- to develop acceptable evaluation criteria, and provide some mechanism for applying these criteria in order to unambiguously identify the preferred proposal; and
- to demonstrate that the method is capable of producing reasonably replicable results.

The question is, given the great complexity inherent in satisfying the above requirements for developing a formal evaluation procedure, is it possible to identify an approach to forecasting and evaluation that will be judged sufficiently valid and reliable to be useful?[3] The next chapter is concerned with identifying theoretical concepts which can provide direction for satisfying these requirements.

DISCUSSION

This chapter has been concerned with defining the central problem addressed by this dissertation, exploring the context of this problem, and establishing the general rationale that guided research into the problem and eventually led to a proposed solution. Attention has been drawn to the great complexity of resource decision making, and the need for resource management decisions to be informed by a practical methodology for environmental evaluation based on explicit evaluation criteria. In addition, special procedures are needed for evaluating resource allocation proposals which are particularly complex and controversial.

Although many resource allocation conflicts can be pre-empted by careful planning, or ultimately resolved through sympathetic assessment and patient negotiation, there are some cases - usually the classic "development vs. conservation" situations - when two or more groups are not prepared to compromise, and the alternatives they put forward differ in such fundamental ways that they must be regarded as mutually exclusive. In such cases there is usually strong disagreement as to which alternative would be in the best overall interests of society, and very often a major and irreversible commitment of resources is involved.

Thus two very broad but important categories of resource allocation proposals have been defined: those which are relatively noncontroversial, and those which are highly controversial. The former category does not present any significant problems of evaluation or decision making, and therefore relatively informal and narrowly-based evaluations will usually suffice to guide the decision making process. But with highly controversial resource allocation proposals, contending groups are mistrustful of an informal evaluation process and inclined not to accept an unfavourable decision. For these cases there is a need for a formal evaluation procedure that will be respected and accepted by all concerned parties.

As defined in this dissertation, then, evaluations can be either informal or formal. An informal evaluation is characterized by the application of individual judgments in an *ad hoc* or unsystematic manner; in addition, the major subjective judgments which give rise to a decision or position are usually not clearly communicated, so that the underlying attitudes, opinions and values in any pronouncements on the subject of the evaluation tend to be obscured. A formal

3 Appendix C elaborates on the need for a formal method of evaluation which will have widespread acceptance, and discusses in greater detail the principal considerations in developing such a method, and the specific obstacles that must be overcome.

evaluation, by contrast, is characterized by individual or group judgments which are applied in a rigidly-defined and systematic manner; in addition, the process requires overt expressions of the major judgments involved, so that subjective value judgments are made explicit.

Over the past few years, there has been a trend away from more sophisticated (and quantitative) formal evaluations toward simpler (and more qualitative) informal evaluations (Bisset, 1980; Lee, 1982; Hollick, 1986). Common practice is to rely on Environmental Impact Assessments to provide the information needed to conduct informal evaluations (or relatively unsophisticated formal evaluations), even for controversial resource allocation proposals. These evaluations, performed by environmental planners and analysts (and then again by decision makers, when reviewing the impact report), can provide the basis for a process of negotiation and compromise with concerned parties to find a satisfactory solution to the resource allocation problem.

The experience to date indicates that this approach is appropriate to most resource allocation decisions, but not to all: there are many examples of decisions which have been hotly-contested because affected parties felt that the evaluation process was inadequate. For example, in South Africa there has been considerable controversy over proposals to allow diamond mining in an area wanted for a national park, to develop a granite quarry in an historic wine-farming area, to create a marina in an urban wetland, to flood a valley acclaimed for its conservation value, to allow a modern housing development in a rustic coastal village, and to build a four-lane highway through an exclusive metropolitan residential area (see the case studies in Chapters 4, 5 and 6). The great conflict that has arisen in situations such as these indicates that the evaluation process associated with current Environmental Impact Assessment methods is inadequate, and there is a real need for a more formal and sophisticated method of evaluation that can be applied to resource allocation proposals which prove to be especially controversial.

To sum up, the central problem addressed in this dissertation is that some resource allocation proposals are especially contentious and intractable, and give rise to substantial controversy and dissension. This creates a situation which presents great difficulties to the party responsible for making the decision, as well as great anxiety and distress amongst those who will be affected by the decision. Under such circumstances a full and rigorous evaluation is eminently to be desired, using procedures that are clearly understood and acceptable to all concerned parties. There is thus a need for a formal method of evaluation, especially designed for controversial resource allocation proposals, that will be regarded as both reliable and satisfying by decision makers and affected parties.

To prepare the way for the development of a formal method of evaluation, this chapter has been concerned with examining the general nature of the resource decision making process, and particularly the relationship between environmental assessment, environmental evaluation and decision making. The next chapter is concerned with establishing the theoretical foundations of a general environmental evaluation methodology which will feature a specific method for evaluating controversial resource allocation proposals.

CHAPTER 3

THE THEORETICAL FOUNDATIONS FOR THE DEVELOPMENT OF AN ENVIRONMENTAL EVALUATION METHODOLOGY

OVERVIEW

In order to gain general approval and acceptance, an environmental evaluation methodology for improving resource allocation decisions needs to be regarded as being theoretically sound. The theoretical foundations for the development of an evaluation methodology are discussed in this chapter.

Since resource decision making involves choosing between alternative allocations of scarce environmental resources, and since this involves making judgments as to the relative social value of the anticipated outcomes for each alternative, the essential nature of the problem is to develop a suitable approach to decision making, evaluation and measurement. This involves formulating

- decision procedures (to guide decision making)
- evaluation procedures (to inform the decision making process), and
- measurement procedures (to inform the evaluation process).

The major theoretical constructs used in the development of the evaluation methodology, therefore, are derived from decision theory, economic theory, and measurement theory.

The chapter begins by examining the general nature of decision making, and exploring alternative ways that resource allocation decisions can be made. The kinds of questions that should be asked when considering a controversial resource allocation proposal are identified, and this serves to highlight the great complexity of the problem.

Then two broad approaches to resource decision making are identified and discussed. One is a procedure based on principles of "political rationality", which is directed at searching for a course of action that, while probably not optimum, will be widely regarded as "satisfactory". The other is a procedure based on principles of "economic rationality", which can be used to determine which of two or more competing proposals is in the "best" interests of society. For practical reasons, it is suggested that the general environmental evaluation methodology should be based on the first approach. But since controversial resource allocation proposals are by definition not acceptable to some parties, it would seem reasonable to base a formal evaluation method for this special class of proposals on the second approach.

This chapter is primarily concerned with developing the theoretical foundations for an approach to evaluating controversial resource allocation proposals. In decision theory, methods and techniques which use principles of economic rationality can be divided into two types. The first type has been designed to utilize the measurements or judgments of decision makers (*e.g.*, Decision Analysis and choice-criterion models), whereas the second type has been designed to utilize the measurements or judgments of a group of "expert advisors" (*e.g.*, Delphi and Nominal Group Technique). Because contending parties involved in resource allocation disputes are likely to favour more broadly-based evaluations, the second type of evaluation model is discussed in more detail.

Attention then turns to economic theory, which provides a way of thinking and a practical guide to action that is eminently suited to the search for improved resource allocation decisions. Cost-benefit Analysis and shadow-pricing techniques utilize measurements of value provided by the market (or judgments by individual consumers) to guide resource allocation decisions. The strengths and weaknesses of these approaches to evaluation are discussed.

Finally, the problem of estimating the value of nonmonetizable impacts is addressed. In order to clearly and unambiguously identify which of two or more resource allocation proposals has the greater social value, it is necessary to measure all the costs and benefits of these proposals so that their net value can be calculated and compared. This leads to recognition of the central difficulty that must be faced in developing a useful method for evaluating controversial resource allocation proposals: *viz.*, obtaining reliable and acceptable measures of utility or significance through some sort of measuring or scaling technique. Accordingly, there is an examination of the principles of measurement theory, and a review of methods that have been developed which may be used for measuring subjective phenomena such as value judgments.

DECISION THEORY

The Nature of Decision making

Decision making is the act of selecting one from among a set of feasible courses of action (Martino, 1972:332). There are many approaches to decision making, but all are concerned with forecasting and evaluating the possible outcomes of alternative actions in terms of one or more objectives, and all are based on some set of premises and decision rules (which may or may not be stated). Very often this process is not formalized, and forecasts and evaluations are obtained by making rather casual, intuitive judgments rather than carefully reasoned, explicit judgments. This is generally not considered a very reliable way to arrive at decisions, and decisions made in this way may elicit little confidence and support among those who will be affected. This is particularly true when the circumstances pertaining to the situation are regarded as being exceptionally complex, when the ultimate consequences of the decision are shrouded in uncertainty, and when the decision affects the availability of resources especially valued by one or more groups. The potential for conflict is increased further when the decision has very different implications for different groups, and is likely to have adverse impacts which at least one group regards as highly significant.

For particularly complex decisions (such as major resource allocation proposals), the original decision making problem can be broken down into a series of problems, each requiring a series of decisions. Easton (1973:350) has pointed out that purely intuitive methods of decision making are not adequate when there are several factors to consider.

> The unaided human mind is limited in its ability to simultaneously consider more than one objective at a time.... Thus, in many instances, the initial intuitive choice is cruder in the sense that it is more likely to have been swayed by predispositions, emotions, and other temporary, but irrelevant influences; and it is more likely to be focused on a single objective.

Usually there are not just one or two but a number of objectives in resource management, and the multiple-use concept has been a dominant resource allocation strategy in many countries for a number of years (Bowes and Krutilla, 1985). Although a sensible and admirable concept, resource management (particularly natural resource management) is complex and often involves multiple <u>conflicting</u> objectives, and so hard trade-offs and hard feelings often underlie (and belie) the harmonious facade of "multiple-use". The reality is that most major resource allocation proposals can result in a number of potential outcomes with vastly different implications for different objectives, and it is usually not possible to maximize several objectives simultaneously (Keeney and Raiffa, 1976:66). Thus there is a need for some formal and systematic approach to multiple objective decision making.

According to Coyle (1972:83), decision theory is concerned with the art of giving bad answers to questions to which otherwise worse answers would be given. The improvement lies in these areas: (1) formal treatment of uncertainty; (2) clarity of assumptions; (3) comprehensiveness; (4) consistency, and (5) specialist techniques.

> The aim of decision theory is to try to supply some aids to the process of decision-making especially where the decision situation involves uncertainty. The idea is that, by providing the analytical framework, the manager will be able to concentrate on supplying the human inputs of intuition and experience one by one without having to try to juggle these in his head, whilst at the same time trying to provide further inputs (Coyle, 1972:78).

The decision making process can be facilitated and strengthened by the provision of a rational analysis - i.e., an analysis that is comprehensive, systematic, and explicit - so that all parties (including the decision maker) can clearly see how the decision was reached, and on what judgments it was based. Then the decision can be reviewed and assessed for reasonableness. By definition, rational analysis is rational behaviour. Rational behaviour is behaviour that is logically consistent, given a set of preferences and acceptable assumptions (Kassouf, 1970:3), and a rational decision can be defined as choice behaviour consistent with the assumptions underlying the model (Green and Tull, 1978:26). The purpose of rational analysis is to eliminate the need for handling on an intuitive basis those pieces of information which can be handled rationally and explicitly (Martino, 1972:341).

When confronted with highly complex, emotionally-charged decision problems - such as the choice between two or more resource allocation proposals which are mutually-exclusive and can be expected to arouse great controversy - the decision maker should ask himself the following questions:

- What is my goal?
- What evaluation criteria should be applied?
- How many objectives am I trying to fulfill?
- Should I attempt to maximize all or some of these objectives, or should I just try to improve on the present situation (and if so, by how much)?
- Is it possible to make progress in terms of all objectives simultaneously (and if not, how can trade-offs be made amongst the competing objectives)?
- How much control do I have over the problem?
- How many decisions are actually required, what is their sequence and when must they be made?
- Who are the other parties with power or influence over the decision, and who are the parties who will be affected by the decision?
- How should these parties be involved?
- Can cause-effect relationships be elucidated?
- How many possible outcomes can be identified?
- Is it possible to calculate the probabilities of occurrence for the various possible outcomes?
- How dynamic or stable is the decision making environment?
- What are the boundaries of analysis?

- How much information is needed?
- How expensive will it be to acquire this information?
- What are my resources (money, manpower, computers, data banks)?
- How much time do I have to make this decision?
- What are the best data gathering procedures for this problem?
- How accurate are forecasts likely to be?
- How do I feel about risk and uncertainty?
- What is the relevant time horizon?
- How much weight should be attached to future outcomes as opposed to more immediate outcomes?
- Can outcomes be measured, and if so can they be measured in commensurate units?

It can thus be seen that the decision making process can become vastly complicated. In addition, major resource allocation decisions can involve hundreds of decisions by dozens of people, each decision depending on previous decisions and influencing subsequent decisions in an interactive and iterative process that sometimes seems to be beyond the control of any single "decision maker". In fact, even the decision making problem can change as new parties become involved or new data becomes available. There is a complex and dynamic network of influences impinging on the resource allocation decision making process, and this complexity and dynamism dictates a flexible approach to making decisions that is geared to coordinate the input of many parties and make use of limited and changing information.

At the same time, there is a need to have a structured approach to decision making and to maintain a coherent view or holistic perspective of the ultimate decision making problem; fragmentation, incrementalism and "ad hocery" can lead to poor decisions. The decision making process must be structured so that it can cope with the evolutionary nature of assessment and evaluation without degenerating into chaos and losing sight of how alternatives actually measure up in terms of the goal and evaluation criteria.

This suggests that there are two fundamental concerns which the decision making process must address. On the one hand, a <u>general procedure</u> is needed to guide thinking, promote dialogue, clarify issues, raise new issues, generate ideas, and otherwise link the different aspects of the decision making problem to improve the prospects of finding a superior solution. This procedure would constitute a methodological framework for conducting the informal evaluations that must be undertaken for any resource allocation proposal, whether controversial or noncontroversial in nature. (Such a procedure - called Integrated Environmental Management - is presented in Chapter 4.)

On the other hand, a <u>specific procedure</u> is needed to identify the "best" overall decision if it does not emerge naturally through application of the general procedure. This more narrowly-focussed procedure would constitute a method of formal evaluation that could be applied to especially controversial resource allocation proposals. (Such a procedure - called the Panel Evaluation Method - is presented in Chapter 5.)

The first procedure would thus be grounded in what will be termed "political rationality" and the second in what will be termed "economic rationality".

Political Rationality vs Economic Rationality

"*Political rationality*", which has been called "bounded rationality" or "procedural rationality" (Simon, 1978), is concerned with the development of procedures for choosing actions which take into account the limitations on human cognition and control. The political system emphasizes this form of rationality, which is based on the idea that since the decision making climate is in constant flux and characterized by great complexity, and perfect information is never available, it is futile to search for optimal solutions. Instead, the decision making process should be concerned with finding a solution that is generally acceptable and likely to be stable, and this can be done largely through consultations with and compromises between affected parties.

In contrast, "*economic rationality*" is based on the idea that sufficient information can be obtained to allow optimal choices. This form of rationality, which has sometimes been called "calculated rationality" (Bjorkman, 1987) and "classical rationality" (White and Hamilton, 1983), is emphasized in classic economic thinking (Simon, 1978). According to this view, greater reliance can be placed on formal evaluation techniques to provide information to society's "decision makers" for deciding what is in the best interests of society.

"Maximizing" behaviour is characteristic of economic rationality, while "satisficing" behaviour is characteristic of political rationality (Coombs *et al.*, 1970; Janis and Mann, 1977; Simon, 1978). Maximizing means finding the "best" solution to a problem. This is generally done by calculating and comparing numerical values (the "bottom line") for a range of alternatives, and thus finding the optimal course of action. The maximizing strategy is based on the assumption that sufficient information can be obtained (at a reasonable cost) to enable the decision maker to:

- identify a set of alternatives which contains the "best" proposal in terms of the specified criteria;
- determine the value of all relevant outcomes associated with each proposal under consideration; and
- make an unambiguous judgment as to which proposal is superior in terms of all the criteria taken together.

Satisficing, by contrast, means finding a "satisfactory" rather than an optimum course of action (Hollick, 1981b; Simon, 1978). The idea behind satisficing is that there are many internal and external constraints acting upon the decision maker's capacity for rationality. Satisficing means the decision maker must construct a model of reality and then behave rationally within the constraints of this model. The general strategy is to define the ranges of possible outcomes that would meet or satisfy major objectives, and then select the action that is likely to achieve one of the satisfactory sets of outcomes. Lopes (In Bjorkman, 1987:29) has said that this approach

> will be displeasing to some because of its inelegance, its vagueness, and its essentially inductive character. But this is the price that will have to be paid if we are to have the kind of useful decision technology that captures and clarifies the concerns of real people in real environments. I do not believe that the decision sciences can afford the luxury of clinging to any theory of rational choice that is simply not sensible.

The differences between these two general approaches are due to different conceptions or models of the decision making environment. Political rationality is based on an open decision model that more closely describes the resource allocation situation than does a closed decision model - there are a nearly infinite array of alternatives at any one time, and new ones are arising all the time. Perfect information is never available because of the complexity of natural and human systems and their interactions, and there are severe cognitive limitations and institutional constraints that preclude the simultaneous assessment of all conceivable alternatives.

Resource allocation problems are usually not well-defined problems; decision makers face complex biophysical and socioeconomic environments and conflicting objectives, so that the decision making environment is always, to some extent, unstructured and ill-defined. In addition, societal objectives tend to be dynamic rather than fixed or unchanging, and the decision maker usually has little control over many important aspects of the situation.

Given a situation in which there are multiple objectives that are dynamic in nature, there can actually be no "optimal" solution apart from making trade-offs or compromises between the objectives that reflect one's values. This means there is no objective optimality, but only consistency between one's goals and values (Einhorn and Hogarth, 1981).

This combination of complex and poorly-defined problems, uncertain outcomes, competing objectives, cognitive limitations, and lack of control makes it difficult to act according to the principles of economic rationality, such as maximizing expected utility (Bjorkman, 1987). Given the dynamic nature of the decision making process, and the limited resources and imperfect analytical measures available, political rationality is more appropriate to most resource allocation decisions than is economic rationality. This is particularly true in the case of policy questions, and choices concerned with identifying or pursuing other broad societal objectives pertaining to resource allocation, such as devising the specific elements of a national conservation policy or a policy on environmental planning and management.

Political rationality would thus appear to be generally more relevant to environmental resource allocation decisions than is economic rationality. Whereas economic rationality assumes that it is possible to enlighten a decision maker so that he can identify some optimal state, and even prescribes a path to the realization of this state, political rationality takes account of the limitations associated with the functioning of the social organism, and recognizes that actions are taken as a result of complex interactions between many people over time. Any one individual has limited control over this complex, iterative process and therefore it is unlikely that optimization can be achieved, even if it can be defined.

Nevertheless, there is still a place for economic rationality in some resource allocation decision problems, particularly for highly controversial proposals, provided that satisfactory and cost-effective ways can be found to deal with their complexity and dynamism, so that the evaluation process is realistic and acceptable to all concerned parties. Economic rationality would seem particularly appropriate in cases when political rationality is likely to break down because of great antagonism, mistrust or lack of understanding. In such cases a formal evaluation procedure which is perceived by all concerned parties to be reasonable and fair could provide an amenable way to break deadlocks in the social and political arenas.

Bakus *et al.* (1982:493) has identified two major processes which can be used to direct formalized decision making: (1) behavioural interaction in the case of groups, and (2) decision analysis for both individual decision makers and groups. Either of these two general approaches could be used to develop evaluation procedures for improving judgments in applying the principles of economic rationality.

Rohrbaugh (1979:73) defines judgment as an inferential cognitive process by which an individual draws conclusions about unknown quantities or qualities on the basis of available information. The individual must screen data in his interaction with an environmental system so that specific inferences might be made. This involves sorting, eliminating and recombining data. Behavioural interaction is directed at improving the judgment process by pooling the special knowledge and insights possessed by members of a group. A major object is to reduce cognitive dissonance and provide cognitive feedback to tap the potential of a group (Hill, 1982). Group interaction has been found to improve judgments (and increase consensus) although there are problems associated with group interactions that lead to process losses (Rohrbaugh, 1979:75). But Hill (1982:535) states that group interaction can lead to process gain through capacity to learn and cognitive stimulation, and his review of this category of methods reveals that group performance is generally qualitatively and quantitatively superior to the performance of the average individual.[1]

Methods based on the behavioural interaction process usually involve the participation of persons who, although they may have no decision making power, are expected to have special insights or credibility which will strengthen the evaluation. While the decision analysis process can also be used by any individual or group, this approach was designed to be used by the decision maker, and is largely concerned with search procedures: what information, at what cost, should be gathered to improve decisions (Simon, 1978). In addition, methods based on this latter approach are directed at eliciting the preference structures of decision makers, based largely on attitudes toward risk and uncertainty (Raiffa, 1968), and they generally involve relatively complex and time-consuming operations for quantifying evaluations. A major difficulty with this approach is that decision makers are often not inclined to collect a lot of information or submit to intricate procedures for estimating probabilities or working out preference orderings (Janis and Mann, 1977).

Lee (1982) suggests that the decision analysis process is of limited usefulness in environmental decision making because people have difficulties in assigning probabilities and do not understand or accept the concept of expected value. Another problem is that decision makers often exhibit inconsistent preferences, which violates a major principle of the modern theory of rational choice, on which the decision analysis process is founded (Hershey *et al.*, 1982; Slovic and Lichtenstein, 1983; Tversky and Kahneman, 1981).

Simon (1978) says that any theory of rational behaviour must take account of the cognitive limitations on decision making: there is great uncertainty and great complexity in dealing with objective and subjective phenomena, so that people may not have great confidence in the quantitative evaluations of a decision maker. In addition, people do not behave in the way that conventional economic theory and decision theory predict - they do not try to maximize expected utility - and therefore Simon (1978) suggests that it is hard to take subjective expected utility seriously as a theory of actual human behaviour in the face of uncertainty. Fischhoff *et al.* (1982) agree that this decision making model does not adequately reflect reality, and that applications often do not work in the real world because of human error or limitations in dealing with complex environmental settings.

These considerations greatly limit the usefulness of methods based on the decision analysis process, particularly in the Third World context, in which confidence in the judgments of decision makers is not always high and the decision making environment is relatively inefficient and unsophisticated. Because complexity in environmental decision making is deep and pervasive, and since controversial resource allocation proposals in particular are characterized by considerable complexity and dissension, it is desirable to develop approximation procedures and heuristics to reduce computational problems and cope with cognitive limitations. Also, concerned parties are more likely to favour methods based on some form of behavioural interaction provided that the participants are respected and their judgments will be accepted. It was decided, therefore, that this class of methods should play a major role in the development of an environmental evaluation methodology.[2]

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1 Both Rohrbaugh (1979) and Hill (1982) have found that group judgments are often inferior to the potential suggested in a statistical pooling model, which suggests the need to more thoroughly examine the variables that affect group process and find ways to further improve group performance.

2 Although behavioural interaction has been selected as the more appropriate approach to formal evaluation in this dissertation, the decision maker may sometimes wish to conduct his own rational analysis of the decision making problem using Decision Analysis (or related methods and techniques) to formalize his personal evaluation of outcomes and trade-offs. Appendix D presents a brief discussion of Decision Analysis and lists some of the more well-known formal methods of decision making based on this general approach. Appendix E presents a brief discussion of Expert Systems, a decision making aid that does not fall neatly into any category but which has great potential for utilizing expert knowledge, experience and intuition to improve resource allocation decisions.

The next section presents a description of two methods based on behavioural interaction. Both of these methods provide approaches to forecasting and evaluation that are specifically designed to be used by groups of specially appointed advisors or counsellors to the decision maker rather than by the decision maker himself. These methods - called "Delphi" and "Nominal Group Technique" - were developed to take advantage of the greater pool of knowledge and insights, and the wider range of value systems, that exist in a group of people.

Delphi and Nominal Group Technique

When decisions are likely to be especially controversial, concerned parties may not be satisfied if the decision is to be based on an evaluation performed by a single individual; they may also not be satisfied if the evaluation is to be conducted by a group of individuals who are thought to have the same (limited) perspective, are obviously biased or have special interests, or are perceived to be vulnerable to pressure or intimidation. In such cases a broad-based evaluation is likely to have greater credibility because it will bring a greater range of experience and insights to the evaluation process. Two procedures that have been developed for conducting group forecasts and evaluations will be presented in this section: Delphi and the Nominal Group Technique.

General Description of Delphi

The Delphi method originated with the Rand Corporation in the 1950's to aid military planning (Pill, 1971:59). The method has since come into widespread use and been applied to a variety of decision making problems (Dalkey and Helmer, 1963; Richey *et al.*, 1985b; Freeman and Frey, 1986; Garde and Patel, 1985; Nelms and Porter, 1985; Sutherland, 1975). Although the evidence is mixed, Delphi is widely accepted as constituting an effective procedure for improving the quality of group judgments (Bardecki, 1984; Hill and Fowles, 1975; Hogarth, 1978; Parente *et al.*, 1984; Rohrbaugh, 1979; Salanick *et al.*, 1971; Spinelli, 1983).

Delphi is a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem (Linstone and Turoff, 1975:3). The method has been described as consisting of techniques of systematic group judgment (Dalkey *et al.*, 1972:2). Delphi is directed at obtaining group judgments to improve decision making under uncertainty and in situations when values are in conflict. Its major attributes include:

- some degree of anonymity for the individual responses;
- some feedback of individual contributions of information and knowledge;
- some assessment of the group judgment or view; and
- some opportunity for individuals to revise views.

The method can be used to clarify judgments, ascertain values and preferences, and stimulate inventive planning. Delphi is most often used to identify measures that might be taken to deal with a given problem situation, and then to assess such measures with regard to their feasibility, desirability and effectiveness (Helmer, 1975:xix).

Most resource allocation problems are characterized by insufficient data, a high order of complexity, and incomplete theory (Pill, 1971:61). When a decision has to be made, and information is lacking or different value systems are involved, the problem is how to make most effective use of existing information and insights, and how to make unbiased evaluations of possible outcomes. It seems reasonable to seek "expert" opinion, but there is often disagreement among experts; in fact, diversity of opinion is a relatively good measure of the degree of lack of knowledge concerning the question (Dalkey *et al.*, 1972:4). The Delphi method is concerned with determining how the diversity of information and feeling that leads to disagreement can be amalgamated to lead to the best available answer to the question.

Delphi can thus be used to accomplish two of the most important and most difficult tasks in resource allocation:

- to forecast outcomes of events that are shrouded in uncertainty; and
- to elicit and make explicit subjective value judgments regarding these outcomes.

The acquisition and analysis of purely objective data are of limited value in approaching such problems, and a systematic method of drawing out and explicitly analyzing basic assumptions and informed intuition can be more useful. The central idea of Delphi is to use "expert" opinion in a highly structured way to merge different points of view into a single group perspective under the assumption that a group judgment is inherently more complete and more accurate than individual judgments (Dalkey *et al.*, 1972:10).

Experiments in group judgment conducted by the Rand Corporation using little known factual data (such as the number of telephones in Africa) have indicated that group judgments are better than individual judgments (Dalkey *et al.*, 1972). These results indicate that the error of the group will be less than the average error of the individuals, and therefore group estimation will generally be safer and more reliable. The validity of group value judgments cannot, however, be "proved" by experiment since there is no way to measure the "correctness" of values. But if one assumes the existence of a set of fundamental values which is common to all humanity yet incompletely perceived by each individual, then a group judgment concerning the relative importance of a set of outcomes might be regarded as more valid than individual judgments. Although each individual's view is incomplete, individuals will tend to recognize the more comprehensive view, so that aggregations of individual models will not only be more valid, but will tend to be accepted as a better, more balanced model (Dalkey *et al.*, 1972:10).

The principal features of the Delphi method are anonymous debate, controlled feedback, and statistical group response. Anonymity reduces the effect of dominant individuals and encourages free expression of opinion; controlled feedback reduces "noise" in the communication process (*e.g.*, emotional "static", extraneous information); and statistical group response reduces group pressure for conformity, facilitates information exchange, and assures that the opinion of each member is represented in the group judgment (Dalkey *et al.*, 1972:20-21).

The actual procedures used in applying the method can vary, but all variations involve an iterative process designed to clarify thinking on the subject and move the group toward consensus. The usual approach is to send a series of questionnaires through the post to members of a Delphi panel. Panelists are asked to perform some operation (*e.g.*, vote on an issue, forecast an event, estimate a number, or rank a list of items), and submit their response to the project coordinator. The responses are tabulated and "feed-back" on group thinking is sent to each panelist along with another questionnaire for the next round. Panelists are asked to compare their own response with the group response, reflect on the possible reasons for observed differences, reconsider their judgments (particularly for those areas in which there is disagreement), and then perform the operation again (perhaps giving written reasons which can subsequently be fed back to the group by the coordinator). This process is repeated until there are no longer any significant changes in the judgments of the panelists. The final iteration is used to assess group thinking on the issue being addressed.

Strengths of Delphi

Delphi has appeal to those people who think a decision maker and his advisors might have too narrow a view (and therefore reject Decision Analysis) and who do not have much confidence in market and shadow-price valuations of resources (and therefore reject conventional economic analysis). The Delphi method is particularly useful under conditions of inadequate factual knowledge when it seems desirable to rely upon the relevant intuitive insights of experts and use their judgments as systematically as possible (Brockhaus, 1975:127). Perhaps Delphi's greatest potential is to stimulate meaningful exchange between people with different viewpoints, and ensure that all aspects are considered in a rational and dispassionate way. A major problem in controversial resource allocation decisions is polarization and the breakdown of discourse; Delphi provides a set of procedures and a general approach that may be acceptable to all concerned parties, and may lead to greater understanding and acceptance of diverse points of view.

In addition to providing judgmental input data for use in specific studies in which accurate information is unavailable or too expensive to obtain, Delphi can strengthen evaluation models which require subjective inputs to the point where they become the dominating parameters (Linstone and Turoff, 1975:10). The method can also provide a systematic and objective process for gathering expert opinion on a regular and continuing basis to improve the general quality of decisions (Helmer, 1975:xx).

Limitations of Delphi

Practitioners have experienced difficulties in applying Delphi. "Experts" are not always easy to define or identify, and people with special expertise in a particular field tend to be conservative and extrapolate from the past to the future (Pill, 1971:62). If questionnaires are used, panel attrition can be a problem. Another major potential problem is that the project coordinator is in a position to bias the panel with selective information or control procedures (Richey *et al.*, 1985a). For example, different internal procedures, wording of event statements, and selection of panel members can affect reliability. In addition, a pre-selected set of event statements can significantly bias the outcome (Hill and Fowles, 1975:180).

Bias and confusion can arise in other ways. Events to be judged are usually treated independently of one another, but there may be significant interaction between events. If the panel members do not share common perspectives, panelists may not have the same interpretation of what is being judged. It is unlikely that any panel can possess the full range of human values and insights that can be found in a complex and heterogeneous society, and so value information and specialized knowledge from some groups will not be represented. And for problems that involve human interactions over a significant time period, it may be impossible to predict or value events (Shafer and Moeller, 1981:5).

A major potential problem is the tendency for panelists to change their judgments to correspond with those of the group; there are subtle psychological pressures to conform to group opinion. For example, attention is naturally drawn to areas of diverging views so that if there if reasonable agreement on a point there is little incentive for individuals to reconsider, even though further consideration might result in a new judgment that is further from the group judgment. At the same time, an individual is inclined to search more assiduously for reasons why others have judged a matter differently, and then is more inclined on discovering possible reasons to change his view to be more in conformity with the group. Also, panelists may agree with the majority just to avoid the effort of reconsidering if they feel the procedure is an imposition or if they have little time or interest in the issue (Ford, 1975:156; Martino, 1972:35-37).

Another major problem arises if panelists are asked to judge the relative significance of items, or make other types of subjective judgments using an interval scale. If neither a zero point nor some other common benchmark from which to scale items can be identified, and if the unit of a utility scale has not been determined, it is not possible to aggregate the measurements of the panelists to obtain a group measurement (see Appendix C). Under these conditions, according to utility theory, it is not meaningful to compare utilities between two or more people (Linstone and Turoff, 1975:580).

General Description of the Nominal Group Technique

The Nominal Group Technique (Delbecq *et al.*, 1975), is another highly-structured method for obtaining group judgments. It differs from Delphi primarily in that there is no concern for preserving anonymity (i.e., opinions can be expressed openly, and there are opportunities for face-to-face discussion), and there is less emphasis on feedback and a form of statistical group response that ensures all points of view are represented in the final presentation. Nevertheless, the method has many similarities to Delphi. For example, there is a "group facilitator" who controls group interaction and ensures that procedures are strictly adhered to, and there are opportunities to change one's thinking after reflection. This technique can also be used to order or scale the output of the group.

Although there are several ways in which this approach to group judgment can be applied, following is a list of typical procedures for conducting a meeting using the Nominal Group Technique.

- The members of the group are presented with some specific task, such as forecasting the consequences of a policy decision, predicting problems associated with a new technology, prioritizing a list of objectives, or identifying the impacts of a proposed development.

- Individuals silently and independently, but working in the presence of the other members of the group, write down their responses.

- When everyone is finished writing, the group facilitator asks one person to read one item on his personal list. This information is recorded in some way visible to the entire group, and then another person is asked to read one item from his list. The process continues in a round-robin fashion until all items on the lists of every member of the group have been formally recorded. No discussion is allowed during this process.

- The group may then be asked to comment on the items that have been recorded. In some cases substantial discussion may be allowed, but always strictly moderated by the group facilitator. Additions, deletions, and other revisions may be made to the group list.

- Group members may then be asked to vote on, order, weight, or otherwise judge the data or perform some mathematical operation on the data.

- The group response is tabulated and the meeting is adjourned.

If the group is very large, it may be broken up into smaller groups, and a group leader may be designated in each group to perform the facilitating function. After performing the above steps, the entire group reassembles and the group leaders present the output of each group; this can be done in the round-robin fashion described above, and the feedback can be limited to the "top ten" items on each group's list. Thereafter the entire group might be allowed to debate the results and suggest changes, and other operations may be required (such as some form of final aggregation).

Strengths of Nominal Group Technique

The Nominal Group Technique approach provides a rational and systematic means for obtaining group opinion in a deliberate and unemotional way. Individuals are stimulated by silently working in the presence of their peers (or persons whom they respect) and are motivated to give careful thought and concise answers to the questions posed. The provision for controlled but open comment and discussion can convey much substantive information clearly and quickly while minimizing the undesirable aspects of group interaction (*e.g.*, effects of dominant individuals). This encourages a fruitful "re-think" of the issues, which may improve judgments. The final output is comprehensive and well-structured, and easy to interpret because all operations are explicit. The method is also satisfying to participants because there is an opportunity to communicate directly to the group if desired - to request or provide information that may be important to group thinking - and there is an assurance that each individual's concerns will be fully recorded and considered by all group members.

Limitations of Nominal Group Technique

There are, however, difficulties associated with the method. Much depends on the abilities of the group facilitator, and there is potential for misunderstandings and emotional reactions during face-to-face discussion that would distort perceptions and inhibit rational thinking, which can affect the quality of the final output. The judgments of less assertive individuals may not be adequately represented if they have declined to participate in discussion or offer revisions. The procedures for aggregating or otherwise mathematically treating the data may not be acceptable to or understood by all participants, and may be subject to manipulation by some of the panelists. Finally, if the larger group is divided into smaller groups, the problems are compounded and there are difficulties in obtaining suitable facilitators and finding access to facilities for conducting several simultaneous meetings.

ECONOMIC THEORY

The Relevance of Economic Thinking to Resource Allocation

The Problem of Scarcity

A central concern of all government authorities with resource allocation responsibilities is how to decide what constitutes the most "*economic action*", or the "best use", of a given set of resources. Resources are here defined to include everything in the environment that can potentially benefit mankind: examples are minerals, forests, soil, wildlife, scenic views, historic buildings, cultural artifacts, clean air, and space for certain extensive recreational activities. Since there are a great many resources with a number of potential uses, and since many resource uses either foreclose other uses or reduce the quality and availability of other resources, resource decision making is complex and often fraught with controversy.

Environmental resource management is concerned with using disciplined and reasoned analysis to reach decisions concerning the problem of how to allocate scarce resources amongst competing ends (Andrews, 1982:281). This is also the concern of the science of economics (Lipsey, 1979). Economists have developed ways of thinking and practical guides to action (see Cost-benefit Analysis in this chapter) that are eminently suited to evaluating alternative resource allocation options. Economic theory therefore provides a rational basis for developing a formal method that is appropriate to evaluating controversial resource allocation proposals.

All economic problems and environmental problems stem from the same root cause: the misallocation of scarce resources. The central problem of resource allocation is how to determine what constitutes the most desirable combination of benefits that can be derived from a given set of resources given the "*opportunity costs*" that are involved. Since the science of economics addresses the fundamental reality of scarcity, recognizes the inescapable necessity of bearing opportunity costs, and is concerned with the problem of making intelligent choices in the allocation of scarce resources, an examination of the principles and concepts of economic thinking would be relevant to the development of a research methodology for environmental evaluation.

A common practice in applying economic thinking to resource allocation problems is to calculate and compare the "*present discounted value*" of alternative proposals. This involves forecasting the value of all costs and benefits over a specified time period and then discounting the value of future costs and benefits back to present value equivalents. The result is a measure of the relative efficiency of the proposals, and it is widely assumed that the proposal with the highest present discounted value should be selected.[3]

But efficiency is not the only consideration in making resource allocation decisions, and money is not the only measure of value. While monetary measures play an important role in

3 Appendix F presents a discussion of why measures of present discounted value cannot be regarded as a reliable indication of the value of a proposal.

economic analysis, economic decisions do not require that gains and losses be expressed in monetary terms. According to Samuelson (1973:6)

> "... economics is the study of how men and society end up choosing, with or without the use of money, to employ scarce productive resources that could have alternative uses, to produce various commodities and distribute them for consumption, now or in the future, among various people and groups in society. It analyzes the costs and benefits of improving patterns of resource allocation."

For many years, conventional economic thinking paid relatively little attention to costs and benefits associated with those environmental resources which could not be "priced" (Dohan, 1977; Godwin and Shepard, 1979; Gregory, 1979; Hardin, 1968, 1977b). Environmental services have long been regarded as "*(pure) public goods*" (Maler, 1985:10), and because they seemed to be in great supply little concern was shown for them. Hardin (1968) drew attention to the fact that some of these goods were vulnerable to growing population and development pressures, and since then economists have paid more attention to this special category of public goods: "*common property resources*" (Smith, 1978; Smith and Krutilla, 1979).

But even today, many common property resources are often ignored completely in resource evaluation, or else analysed in a very perfunctory manner, and the only inputs and outputs that are explicitly or seriously considered are those that can be traded in the market or expressed in monetary terms. The traditional list of economic resources include labour, capital and land (Lipsey, 1979), but those components or aspects of "land" which could not be exchanged in markets - such as ecological processes, biological species, and major geographical features - often play a relatively small role in economic analysis (Randall and Castle, 1985). There are three major factors that give rise to this situation (Daly, 1987):

- because they cannot be "owned" and traded in the market, a price cannot be determined for common property resources through the interaction of supply and demand, and so these resources are extremely difficult to value;

- it has been widely assumed that common property resources are not particularly scarce or essential to continued economic growth; and

- there has been a pervasive belief that general technological advance and the responsiveness of market feedback mechanisms will compensate for any losses of these resources.

Many economists still regard the natural environment and its functions as being virtually inexhaustible (Beckerman, 1972, 1974; Common, 1988; Seneca and Tausigg, 1979). But a series of environmental crises in recent times (Allen, 1980; Global 2000 Report, 1980; International Union for the Conservation of Nature, 1980; Rees, 1985; Westman, 1985; World Commission on Environment and Development, 1987) has stimulated considerable debate as to whether this is in fact so, and has led to recognition of the fact that losses of certain natural amenities and ecological functions can lead to a situation in which the economic gains of resource exploitation are outweighed by losses in environmental quality and greater risks to survival.[4] It is in fact possible to enter a situation in which lower levels of social well-being, due to a reduction in environmental quality from the loss of environmental services, cannot be arrested or reversed by greater economic growth or a reallocation of resources (Dohan, 1977; Fisher and Krutilla, 1985). This realization has resulted in greater attention being given to the concept of "externalities", and spurred a search for ways to incorporate external costs and benefits into economic analysis.

It is now widely recognized that resource allocation decisions should not simply be concerned with the provision of raw materials and other marketable resources needed to create capital goods or bring about more efficient production of consumer goods and services. In order

4 Appendix G examines this debate and presents a line of argument intended to refute the suggestion that there is no significant danger that resources will be exhausted.

to improve resource allocation decisions, it is necessary to develop reliable methods of evaluating all the implications of resource allocation proposals: there is a need to identify and value the entire spectrum of inputs and outputs associated with alternative proposals, whether the various inputs and outputs can be priced by the market or not, in order to compare the total effect of the respective proposals on social well-being.

The Concept of Costs and Benefits

Economic thinking is based on utilitarian principles. The central idea is that resources have utility and the object of consuming resources is to receive that utility. Although no one has yet devised a way of measuring utility, people daily make choices which demonstrate their ability to discern which of two resource allocation options has greater utility. People base these choices on their perception of which option will confer the greater net benefit (i.e., yield greater utility after costs have been deducted from benefits).

Economic theory accords with common experience and intuition: there are advantages and disadvantages associated with almost every action, and it seems desirable to base choices on perceptions of which alternative will confer the greatest advantage. If a given set of resources can be shifted from one use to another use which offers even greater net benefits, then it makes sense to employ the resources in the alternative use.

But in practice, these choices are not simple: any resource use will result in a number of outcomes, each of which may be regarded, from a particular individual's point of view, as either a cost or a benefit. Some individuals may perceive certain outcomes as costs, while others may perceive the same outcomes as benefits; and even if there is agreement as to whether an outcome is a cost or a benefit, the actual valuation will differ from individual to individual, and most of the costs may be borne by one group of individuals, while most of the benefits fall to another group of individuals. The science of economics is largely concerned with analyzing such problems, and these are precisely the problems that characterize controversial resource allocation proposals. Such controversies arise from different perceptions of:

- what constitutes a cost or a benefit (i.e., whether an outcome should be considered adverse or beneficial);
- how great the costs and benefits are, and whether there is a net benefit (and if so which proposal has the greater net benefit);
- and how these costs and benefits will be distributed over the population, including future generations (and whether this distribution may be regarded as being fair or equitable).

In analyzing both microeconomic problems (which concern the relationships between individual producers and consumers, and the resulting allocation of resources) and macroeconomic problems (which concern relationships between broad economic aggregates), economic theorists are concerned with the problem of identifying and evaluating costs and benefits (or "gains and losses", "advantages and disadvantages", or "goods and bads"). But there are two schools of thought about how to approach economic analysis, and this has given rise to two very different economic disciplines: positive economics and normative economics.

The Development of Environmental Economics

Positive economics is concerned with matters of fact rather than matters of values and ethics (or "what is", rather than "what ought to be"), whereas normative economics is concerned with describing how the current reality should be altered to bring about a more desirable state (Bannock et. al., 1978). Positive economics purports to be "value-free" and objective, and is concerned only with understanding the functioning of economic systems in order to strengthen its predictive powers. Normative economics, by contrast, assumes certain goals and objectives which are obviously "value-laden" and subjective, but which are based on explicitly stated premises, and is concerned with furthering these goals and objectives in order to strengthen the social relevance of economic analysis (Lang, 1980; Mishan, 1981; O'Brien, 1981).

Normative economics has had an important influence in the development of two major branches of economic thinking: welfare economics and environmental economics. Both of these approaches to economic analysis are based on defining and applying tests or criteria to determine whether a proposal will result in improvements in welfare or not. Whereas the approach of positive economics in microeconomic analysis is largely directed at simply measuring the relative efficiency of alternative actions (on the assumption that an improvement in efficiency constitutes an improvement in welfare, and in the belief that sufficient factual evidence can be obtained to make this type of measurement), welfare economics is concerned with judging the distributional consequences of actions as well.

In welfare economics, there are thus two major criteria by which to judge actions - efficiency and equity - and therefore an action which excels in terms of efficiency may not necessarily be the preferred action. Welfare economics has been defined as that branch of economics concerned with ranking alternative economic situations on a scale of better or worse (Mishan, 1981:3) and this is done by applying and trading-off these two evaluation criteria. While it is generally agreed that efficiency can be evaluated in terms of a "*potential Pareto improvement*", several standards have been suggested for evaluating equity improvements, and there is as yet no agreement as to how to objectively apply these standards or to make trade-offs with efficiency (Hardwick et. al., 1986:129-132).

In recent years another branch of economics has emerged: environmental economics (Cottrell, 1978; Gorrie, 1979; Kneese, 1986; Kneese and Schulze, 1985; Pearce, 1988; Stauth, 1983a). Like welfare economics, environmental economics is concerned with efficient production and equitable distribution in the allocation of resources, but its focus is on the environmental implications of production and consumption activities. This rapidly evolving field of study differs from welfare economics in two fundamental ways:

- there is an explicit and overriding concern with the problem of evaluating the utility of those environmental resources for which property rights cannot be specified, and which therefore cannot be priced and allocated efficiently through market mechanisms; and
- there is an implicit concern with the problem of ensuring that future generations will be left with the means to enjoy a satisfying existence.

As mentioned earlier, this latter consideration is not regarded by some environmental economists as a particularly significant problem, but others have suggested that present environmental conditions are such that, for the first time in history, the well-being of future generations is in serious doubt.[5] If the situation is as serious as some environmental scientists claim it to be, then the social welfare function needs to be re-defined and new resource allocation rules need to be formulated. Herfindahl and Kneese (1974:389-390) have stated that any theoretical approach to the problem of economizing in this situation which gave substantial weight to the well-being of those living later would end with very high valuations for actions that would avoid sacrificing "environmental flows". In fact these authors have suggested that actions which foreclose return to the prior situation should be avoided:

> Our own entry for consideration as a modification of the social welfare function is a modest one that would be compatible with a variety of philosophic-religious positions: Our actions should not be such as to foreclose the attainment of a position with respect to nonexhausting resources by future populations that is attainable by us.[6]

5 For a fuller discussion of this debate, see Appendices F and G.

6 This idea is further elaborated in Appendix G.

This line of thinking suggests that in addition to the efficiency and equity criteria, one should explicitly consider the flow of costs and benefits to future generations. In accordance with this suggestion, the field of environmental economics as it is understood in this dissertation is concerned with the implications of resource allocation decisions not only in terms of efficiency and equity (i.e., the welfare effects on existing populations), but also in terms of the intergenerational consequences of such decisions, or the "sustainability" of the flow of net benefits over the very long term. This new criterion may be referred to as the "intergenerational" or "sustainability" criterion.

Thus environmental economics as it is understood in this dissertation does two things which distinguishes it from other branches of economics:

- it extends the subject matter of concern beyond those goods and services which can be priced and exchanged in markets to encompass all environmental considerations (both priced and unpriced goods and services); and

- it extends economic analysis over intergenerational time periods.

The reasoning is that economic concepts can be applied to all facets of the general resource allocation problem, including long-term environmental problems. This is because the problem of allocating unpriced environmental resources is characterised by exchange or allocative mechanisms (just like more conventional economic problems), which directly or indirectly regulate activity, and which result in a certain pattern or flow of costs and benefits to different groups, including future generations.

Environmental economics, therefore, might be defined as that branch of economics concerned with ranking alternative environmental situations on a scale of better or worse (Stauth, 1983a:83). In this definition, the term "*environmental situations*" is to be given the broadest possible interpretation, and is understood to include everything, from physical objects to ideas, that surrounds and impinges on the well-being of the individual, the group, and society as a whole. The term is also understood to include both present and future things, and the scope of the analysis includes the problem of judging what is better or worse for future individuals, groups and societies.

Thus defined, environmental economics would appear to be an unwieldy discipline, almost incapable of being put into practice. But although the difficulties are daunting, it is of crucial importance that the analytical problems be addressed because there may be little time to meet these challenges: resource allocation problems are becoming more complex, involving a greater number of unpriced environmental goods and services of increasing scarcity value, and having more profound implications over longer-time horizons. Rather than shirk the difficulties because of insufficient theoretical development, or because perfect analytical tools are not yet available, the task is to try to strengthen the theoretical framework and then to develop practical methods and techniques for applying theory, so that resource allocation decision making can be improved now.

One part of the theoretical framework that is particularly important to applied environmental economics is the development of practical guidelines for project appraisal (Pearce, 1988:35). An environmental evaluation methodology must provide acceptable methods and techniques for measuring the significance of environmental impacts and for ranking alternatives according to the selected criteria. One well-established but much criticized method for evaluating major resource allocation proposals, Cost-benefit Analysis, is discussed in the next section.

Cost-benefit Analysis

Decision Analysis and related methods (see Appendix D) were designed to use the judgments and preferences of the decision maker in conducting forecasts and evaluations of alternative courses of action. Delphi and Nominal Group Technique were designed to use the judgments and preferences of "experts" in accomplishing these tasks. In Cost-benefit Analysis (also sometimes called CBA, Social Cost-benefit Analysis and Benefit-cost Analysis) an attempt is made to evaluate alternatives on the basis of the preferences of the individuals and groups who could be affected by the action. This is done by estimating the value that people attach to the outcomes of alternative actions. There are two general approaches to obtaining these estimates: observing revealed preferences or recording expressed preferences. The first approach (revealed preferences) is to observe actual behaviour in a market or a "surrogate market"; the second approach (expressed preferences) is to invent a "hypothetical market", and ask people their willingness to pay to gain some unpriced good, or the amount of compensation they would demand to forego some unpriced good (Pearce, 1983:10-11). When the net effect of each alternative has been calculated, one can identify the alternative which would have the highest net benefit. One can also make judgments about the distributional consequences of the various alternatives (Abelson, 1979; Gregory, 1979; Layard, 1972; Pearce, 1983).

General Description

Since all potential outcomes of resource allocation proposals can be regarded as either adverse or beneficial impacts, which can in turn be regarded as social costs or benefits, Sassone and Schaffer (1978:132) have suggested that a social cost-benefit framework be used to evaluate the outcomes of any resource allocation proposal. There are two difficulties with this suggestion. First, many costs and benefits cannot be measured accurately, and others must be measured in incommensurate units. Second, Cost-benefit Analysis is primarily directed at judging the efficiency of alternative courses of action, and efficiency is only one criterion that might be applied to resource allocation proposals.

Nevertheless, outcomes relevant to other criteria, such as intragenerational and intergenerational distribution effects, can also be expressed in terms of costs and benefits and, several techniques (such as "extended Cost-benefit Analysis") have been developed for addressing other criteria within the general framework of Cost-benefit Analysis (Biswas and Geping, 1987; Pearce, 1983; Rees, 1985; Schramm, 1973). Provided that the commensurability problem can be resolved, there would appear to be considerable merit in adopting the concept of using costs and benefits to link all relevant criteria and facilitate trade-offs between them. The relatively new discipline of environmental economics would seem eminently suited to broaden the horizons of Cost-benefit Analysis since it is specifically concerned with the problems of incorporating unpriced values in the cost-benefit framework, and finding ways to compare outputs of alternatives in terms of their intertemporal effects (Pearce, 1983, 1988).

In a free-market economy, many resources are allocated according to market valuations of their utility, and this is generally considered to be a highly efficient mechanism for allocating resources (Pearce, 1983). But some resources ("common property resources") are not traded in the market, and very often important outcomes of an action cannot be "priced", or cannot affect the price of those outputs with which they may be associated. When market evaluation is unacceptably deficient (which it often is), the prices that emerge in the market must be supplemented or replaced by explicit public evaluation (Gregory, 1979:15). Cost-benefit Analysis is a procedure for estimating and evaluating net benefits associated with alternatives for achieving defined public goals (Sassone and Schaffer, 1978:3). This procedure is concerned with identifying all of the costs and benefits associated with an action, measuring their value in commensurate units (usually monetary values), discounting the value of all future costs and benefits at an appropriate rate of discount, and then adding these present value equivalents to obtain the net present discounted value of the action. If this value is positive the action is efficient; if it is negative the action is inefficient. If one alternative has a higher present discounted value than any other, and the decisive criterion is efficiency, then it is to be preferred over others (Stauth, 1983a:100).[7]

7 Several difficulties associated with present discounted value measures are discussed in Appendix F.

Cost-benefit Analysis was developed by federal water agencies in the United States to evaluate water resources investments (Kneese, 1984:1; Pearce, 1983:14). The Flood Control Act of 1936 proposed a feasibility test for flood-control projects which required that the benefits of a project exceed its costs. The resulting experience eventually led to the issuance of a document entitled Proposed Practices for Economic Analysis of River Basin Projects which provided guidelines on how to conduct Cost-benefit Analysis. In time, other U.S. agencies adopted Cost-benefit Analysis practices to analyze the economic and environmental consequences of other types of projects, as well as new technologies and scientific and regulatory programmes (Hardwick *et al.*, 1986; Pearce, 1983). In 1981 Executive Order 12291 required Cost-benefit Analysis for any major regulatory action undertaken by any branch of the U.S. federal government; since that date there has been considerable research into ways to improve Cost-benefit Analysis and yet, according to Kneese (1984:ix), the available tools are still relatively crude and untested.

The central principle of Cost-benefit Analysis is that before adopting any proposed action, it should be demonstrated that the costs of that action will not exceed its benefits (Mishan, 1975; Pearce, 1983). The assumption is that if costs will exceed benefits, then it would be better to use the resources in some other way that would yield a net benefit, or to take no action (the "null" alternative) and maintain the *status quo*. Even if an action would have a net benefit, if some alternative action would yield even greater net benefits, then all other things being equal, the alternative action should be regarded as superior.

Although there may be some situations in which the well-being of society could be improved by taking an inefficient action, it seems reasonable as a general rule to require proposed actions to be efficient. Nonetheless, it does not follow that the most efficient action in a particular case should be adopted. If an action would result in a reallocation of resources so that at least one person is made better off without anybody else being made worse off, that action would meet the "*Pareto criterion*" (Lipsey, 1979) and so would constitute an unambiguous improvement in social well-being. But this is seldom the case; in fact, almost any major resource allocation decision will make someone worse off. In addition, the most efficient action may sometimes have unacceptable distributional consequences or violate other evaluation criteria (*e.g.*, will have inordinate adverse impact on a particular social group, or on future generations).

As already mentioned, Cost-benefit Analysis is primarily directed at providing a measure of the "efficiency criterion", which can be defined as making a "potential Pareto improvement" (Lipsey, 1979): if the gainers from an action can potentially compensate the losers and still be better off than they were before, then the action is efficient. In practice, gainers seldom adequately compensate losers, and so some trade-off is necessary between the efficiency gain and distributional consequences (Okun, 1975), as well as effects in terms of any other criteria which have been specified, in order to make a judgment as to the overall effect of a proposed action on social well-being.

Although primarily concerned with measurements of efficiency, Cost-benefit Analysis is a widely used method of evaluating resource allocation options, and can provide information that is relevant to applying and trading-off different criteria for judging any resource allocation proposal. For example, if benefits are found to exceed costs, the action is efficient; if costs and benefits will be distributed fairly over the population, the action is equitable; if benefits exceed costs for future generations, the action has positive intergenerational effects (Stauth, 1983a:99). Therefore, the cost-benefit framework constitutes a promising approach to evaluating controversial resource allocation proposals.

While other forms of project appraisal often result in fragmentation of analyses into partial statements covering "economic", "social" and "environmental" impacts, Cost-benefit Analysis incorporates all impacts (which can be regarded as either costs or benefits) into one analysis (Sassone and Schaffer, 1978:131). Distributional and intergenerational effects can also be displayed and weighed against measures of present discounted value (Sassone and Schaffer, 1978:23-24). While Cost-benefit Analysis is primarily concerned with determining the overall efficiency of prospective actions, according to Gregory (1979:4) the analysis is also properly concerned with identifying all the individuals or groups affected, evaluating their respective gains and losses and comparing the aggregates.

Example of a Cost-benefit Analysis

Dohan (1977:152-166) describes the general approach of Cost-benefit Analysis and provides an example which is concerned with determining whether the value of a wetland that is maintained in its natural state would outweigh the value of a development which would eradicate the wetland. This example is briefly recounted here to illustrate the four basic steps to Cost-benefit Analysis described by Dohan:

- identification of alternative projects (including the "null" alternative, or doing nothing);
- quantification of all of the benefits and costs from each project;
- finding "shadow prices" and determining the economic value[8] of benefits and costs; and
- choice of projects.

Step 1: Identification of alternatives

In this example, it is assumed there are only two viable alternatives: an unspecified "development" which involves filling in and building on the wetland; and the null alternative which would leave the wetland in its natural state.

Step 2: Quantification of benefits and costs

In Dohan's example, the costs and benefits of the development are all financial in nature so that market prices can be used to express their value. The costs of the null alternative (maintaining the wetland) are nil. The wetland offers several unpriced benefits, which are associated with a range of ecological and amenity functions. These include: plant nutrients which enrich coastal waters; food chain links which contribute to fishery production; habitat for fishes and other marine life of value to man; habitat for wildlife (including endangered species) of recreational, aesthetic, and scientific importance; natural features which offer a wide variety of recreational opportunities and special aesthetic pleasures; storage and release mechanisms affecting flood control and the supply of water; ecological mechanisms for processing and assimilating the waste products of civilization; a buffering system against storm events; and finally, unknown functions or potential benefits that may be of considerable value now or in the future. These wetland benefits are summarized in Dohan's example as follows:

- increases productivity of fishing industries
- provides habitat for wildlife
- contributes to the preservation of endangered species
- provides recreational opportunities
- provides open space amenity
- constitutes a visual amenity
- provides public service functions
- keeps options open.

8 Dohan uses the term "economic value" to mean any value which can be expressed in monetary terms (to be distinguished from social and other values which are generally regarded as nonmonetizable).

Many of these benefits cannot be meaningfully quantified, which means that the analysis will be incomplete and biased: the relative efficiency of the development and the wetland cannot be conclusively determined if the socially relevant output of the wetland ecosystem cannot be completely enumerated and quantified. Nevertheless, the uncertainty and bias can be reduced if it is possible to model successfully the relationship between loss of a given area of natural wetland and the reduction of some of these outputs. For the purposes of this example, Dohan assumes that this relationship can be modeled (and reduction in output can therefore be quantified) for three of the benefits listed: productivity of fisheries, recreational opportunities, and public service functions.

Step 3: Finding shadow prices and determining economic values

Several techniques can be used to determine "*shadow prices*" for unpriced costs and benefits (see Shadow-pricing Techniques in this chapter). For example, assume it could be determined that the loss of nursery areas for young fish, and the reduction of food supply to offshore fisheries, will reduce the annual fish catch by $100 per acre of filled wetlands per year. If the social rate of discount is 6%, then the net present discounted value of this stream of foregone benefits is $1,662.

The value of recreational opportunities can be estimated by such measures as user fees, equivalent commercial value of the recreational catch of fishes, willingness to pay surveys, and differential property values. The value of public service functions can be estimated by calculating the added economic resources that would be needed to partially restore environmental quality after the loss of the wetland, as well as the loss of benefits suffered in moving down to a lower level of environmental quality. Once the annual per acre values for these benefits have been determined, the present discounted value for these two streams of benefits can also be calculated.

While shadow prices might be estimated for other unpriced benefits, Dohan cautions that one should not attempt to assign monetary values to benefits that are distantly related to economic aspects of life and without close economic substitutes. Instead, such nonmonetizable benefits and costs should be boldly listed along with the monetizable benefits and costs, and not dismissed in a footnote as is often the practice (Dohan, 1977:163).

Step 4: Choice of project

In Dohan's example, the costs and benefits of both proposals are discounted at a rate of 6% over a period of 100 years, and the present discounted value of the net economic benefits (i.e., those benefits which can be valued in monetary units) for each proposal is calculated and compared. Box 3.1 presents the results of this hypothetical case. It can be seen that the null alternative has an excess monetary benefit of $12,000, and in addition has significant nonmonetized benefits.

BOX 3.1
Result of Hypothetical Cost-benefit Analysis
(from Dohan, 1977)

WETLAND USES	PDV per acre 6% for 100 years	
ALTERNATIVE 1 : CONSTRUCTION		
	Net Benefits	$10 000
ALTERNATIVE 2 : PRESERVATION		
Recreation	$5 000	
Public Service Functions	$5 000	
Fisheries	$12 000	
(nonmonetized benefits significant)		
	Total Net Benefits	$22 000
(plus significant nonmonetized benefits)		

If the decision rule is to select the more efficient alternative, then the choice of project will be the continued preservation of the wetland. But Dohan points out that there are other important criteria which should be considered in the decision-making process, and it should not be assumed that the alternative with the higher present discounted value will always be in the best interests of society. If, for example, the present discounted value of the wetland had been less than the present discounted value of the development, and it is believed that the social benefit of the development is almost entirely reflected by its present discounted value, whereas the value of several benefits of the wetland cannot be determined with any confidence, then one should not accept as optimum the choice indicated by Cost-benefit Analysis. In this case, according to Dohan (1977:167), the net economic gain of the development (the difference between the present discounted value of the development and the present discounted value of the wetland in its natural state) should be compared with those nonmonetizable benefits foregone by filling the wetland. The decision is then to be based on a combination of political, philosophical, and economic grounds. For example, if the Cost-benefit Analysis had determined that the development had an excess monetary value of $8,000, but the wetlands were one of the few nesting places of an endangered species of waterfowl, one might decide that the relatively small gain in economic benefits is meager compensation for the possible loss of a species.

Dohan thus concludes that Cost-benefit Analysis has important limitations, but is still a most useful analytical tool. If, in the case just mentioned, it is decided to accept the economic costs of preserving the endangered species, economic criteria are not being rejected but rather integrated into a broader context of social decision making. For by using Cost-benefit Analysis, it is easier to conceptualize the real trade-off between net economic benefits and what are traditionally regarded as purely noneconomic values.

Strengths of Cost-benefit Analysis

Although Cost-benefit Analysis has serious limitations, it is conceptually sound and satisfying. A cost-benefit framework seems a logical way to compare the private and external costs and benefits of alternative resource uses (Dohan, 1977:152). All decisions imply that some assessment of costs and benefits is made, however intuitively. What Cost-benefit Analysis does, amongst other things, is to make these assessments explicit, and this is surely a desirable practice (Abelson, 1979:198). Cost-benefit Analysis reduces the complexity of the decision problem by reducing the number of dimensions; it facilitates analysis by setting the problem in a logical framework; and it forces the decision maker to make a systematic appraisal of the alternatives (Ulph and Reynolds, 1980:52). The method seems particularly appropriate when a proposal has narrow and clearly defined objectives, when the main impacts are physical and readily quantifiable, and when there is a small number of options for achieving the objectives (Barbour, 1980:171).

Limitations of Cost-benefit Analysis

Cost-benefit analysis has important limitations that are of particular concern to resource managers in developing countries: the time, money and skilled manpower requirements for conducting Cost-benefit Analysis are relatively high. In addition, there is considerable resistance to the idea that decisions should be based on monetary measures of outcomes; this is partly because many people feel that important outcomes often concern human values which cannot be represented by money, and also because it seems unfair to use a measure of value (willingness to pay implies an ability to pay) which gives the rich greater "voting power" (McAllister, 1980:143).

Another major difficulty with Cost-benefit Analysis is the problem of determining appropriate boundaries for the analysis: what is significant on a local level may be of no consequence on a national level; but if the boundaries are defined too narrowly, important regional or national costs and benefits, particularly from higher-order interactions or cumulative effects, might not be considered (Odum, 1982; Tribe *et al.*, 1976:5).[9] In addition, many conventional applications of Cost-benefit Analysis do not take adequate account of distribution effects (Hardwick *et al.*, 1986; Mishan, 1975; Pearce, 1983; Simon, 1974) and the implications of development for future generations (Daly, 1987; Feldstein, 1972; Goodin, 1982; Kneese and Schulze, 1985; Layard and Walters, 1976; Mueller, 1974; Page 1977; Pearce, 1983, 1988; Price, 1973; Sharp, 1981). For example, while it is generally considered appropriate to discount the value of costs and benefits to be incurred in the future (Pearce, 1983), one should somehow take into account the different nature of the benefit streams associated with preservation and development. There is a problem if the net benefits of preservation are rising faster than the net benefits of development, because then assessing the projects on the lifetime of the development (say 20 years) will bias the analysis in favour of the development project since the future greater benefits of preservation will have been ignored (Arrow and Fisher, 1974; Fisher *et al.*, 1972, 1974; Fisher and Krutilla, 1985; Krutilla and Cicchetti, 1972; Krutilla *et al.*, 1972; Ulph and Reynolds, 1980:131-132).[10]

Many resource allocation decisions involve considerations of risk (when the probability of events can be estimated) and uncertainty (when the probability of events cannot be estimated). Levels of risk and uncertainty are important to decision makers and their constituencies: people are prepared to suffer some opportunity costs to reduce risk (such as risks associated with major hazards or with irreversible actions that would foreclose future options), and if the risks of a project are high then its benefits must be very high to be acceptable. While there is no universally accepted approach for dealing with uncertainty, risk values can be calculated by estimating "expected damages" for each year and then discounting these values back to present value (McAllister, 1980:113). But this is seldom done. In addition, Cost-benefit Analysis is not well suited for assessing the dynamics of a situation; it does not have the ability to adapt or adjust a strategy to account for information acquired along the way. This is especially important for problems with long time horizons (Bell *et al.*, 1977:9).

Finally, most practitioners of Cost-benefit Analysis tend to pay little attention to those costs and benefits which cannot be easily expressed in monetary terms, or clearly quantified in some way, and they also tend to consider the ultimate goal of resource allocation to be maximization of national income rather than the maximization of social welfare (Herfindahl and Kneese, 1974:222). The attempt to collapse all evaluations into a single number often distracts attention from other important welfare criteria and may not serve decision makers well. The decision maker needs various kinds of information, not summable into a single number, as a basis for political decision (Herfindahl and Kneese, 1974:.223). Irreversible processes, quality of life, risk avoidance, distributional effects, incommensurability, and ethical considerations are not adequately addressed in conventional Cost-benefit Analysis (Barbour, 1980:179). The significance of such considerations is especially great for those decisions which may result in large changes in the availability of resources which have no close substitutes (Dohan, 1977:168).

But perhaps the major limitation of Cost-benefit Analysis is that value information for many important effects is not readily available or is expressed in incommensurate units. As a result, unpriced impacts are often not adequately considered in Cost-benefit Analysis (McAllister, 1980:142). The key problem is how to handle external costs that are not valued by the market and are difficult to measure.

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9 This is an extremely important problem. No method of evaluation can ensure that a particular proposal's contribution to this cumulative effect is not going to be significant if the effects of other proposals (present and future) are not known. In Appendix G, a case is made for adopting a national conservation policy which would constrain choice in order to avoid incremental losses of natural amenities and ecological benefits beyond a level that would be considered acceptable.

10 Krutilla *et al.* (1972) have developed an ingenious approach to dealing with this problem (see Dynamic Opportunity Cost Valuation in this chapter). Krutilla's approach does not, however, explicitly consider the implications of this problem for future generations. Appendix F presents a discussion of the problem of evaluating resource allocation proposals from the perspective of future generations.

In recent years, a number of sophisticated techniques have been developed to calculate values for unpriced costs and benefits. Several of these techniques are discussed in the following section.

Shadow-Pricing Techniques

The first object in an evaluation is to determine whether a proposal is efficient, so that its efficiency gain can be weighed against other criteria. But when costs and benefits are described in different terms, and measured in incommensurate units, it is extremely difficult to judge the net benefit of a proposal. Finding a way to express and measure all outputs in commensurable terms does not make subjective judgments objective; however, quantification of values can help one judge the relative value of unlike goods, or elucidate the nature of unavoidable trade-offs, and can be a useful analytical procedure for improving the quality of complex decisions.

If costs and benefits are not expressed in commensurate units, decision makers will be forced to compare projects on the basis of two- or three-dozen dimensions (Sassone and Schaffer, 1978). For example, several ecological costs and benefits (which are not directly comparable themselves) may have to be weighed against several social or cultural costs and benefits. This would make the analysis quite unwieldy, and would tend to result in an unsystematic evaluation involving comparisons of a few of the more prominent (or purely arbitrarily-chosen) costs and benefits. There is thus a need to bring all costs and benefits under a common measuring rod, and the most convenient of these is money. Therefore, one approach to reducing incommensurability is to calculate, where possible, shadow or accounting prices for costs and benefits which are not expressed in monetary terms. A "shadow price" is an estimate of the value which would be placed on a good if it could be traded in the market. If all costs and benefits can be expressed in monetary terms (or in any other commensurate units), then they can be summed and the net benefit can be calculated.

Most major resource allocation activities can be expected to result in one or more significant "extra-market effects". These extra-market effects are sometimes called "externalities" by resource economists because they consist of costs and benefits which are external to the decision making processes of the profit-maximizing firm. Even public resource managers often do not take adequate account of external effects associated with resource extraction activities because these effects are difficult to measure, and since they are not priced managers are not always made to feel so accountable for them. The reason why extra-market goods do not have prices is that property rights cannot be vested in them, and therefore their value is not appropriable. This characteristic of inappropriability has tended to cause such goods to be relatively neglected in resource allocation decisions, even though their actual value to society is often very great (Coase, 1972; Hardin, 1968, 1977b). It thus appears that resource allocation decisions systematically favour marketable goods and services at the expense of extra-market goods (such as natural amenities and ecological processes), and therefore resource management fails to reach attainable levels of efficiency.

A major difficulty in applying Cost-benefit Analysis is to find acceptable shadow prices for unpriced costs and benefits (or to find an acceptable way of treating those costs and benefits for which shadow prices are not available[11]). Shadow pricing is a theoretically sound way to estimate the value of nonmonetary effects so these can be incorporated into the cost-benefit framework in order to get a measure of the efficiency of a proposal. Monetary values which emerge in the market for goods and services represent imperfect but widely understood and accepted benchmarks of value against which the value of any environmental good, service, or condition can be compared. Shadow prices may not be precise, but then neither are market prices since there are many imperfections in the market which lead to ubiquitous market failure (Common, 1988; Dohan, 1977; Rees, 1985).

11 Other possible approaches to evaluating unpriced costs and benefits include "threshold valuation" and "dynamic opportunity cost valuation", which will be discussed in the next sections.

There are several approaches to estimating the monetary value of an extra-market good. In some cases, surrogate markets exist for non-marketed goods; in other cases, hypothetical markets can be used to value these goods (Pearce, 1983). Thus two general approaches to shadow pricing have been developed: hedonic pricing includes input valuation, output valuation, and travel-cost valuation; contingent valuation includes survey methods (Brookshire *et al.*, 1980; Brookshire and Crocker, 1981; Brookshire *et al.*, 1982; Brookshire *et al.*, 1983; Dohan, 1977; Farber, 1988; Flowerdew, 1972; Freeman, 1985; Goodman, 1989; Gregory, 1986; Menz and Mullen, 1981; Sinden and Worrell, 1979; Stauth, 1983a; Ulph and Reynolds, 1980).

"Input valuation" measures the value of changing some input to a system by calculating the economic effects that the change will have on subsequent outputs which are sold on competitive markets (Dohan, 1977). The effects of an externality are thereby traced through a system until economic activities are affected. For example, filling in a salt marsh to build a factory along an estuary will reduce detritus and other inputs into the estuarine ecosystem which may in turn reduce the numbers of sports fish in the estuary, which may ultimately reduce the number of sports fishermen visiting the area. This would result in less revenue for bait and tackle shops, hotels, and other businesses (see Figure 3.1). The total economic loss constitutes a shadow price for the benefits generated by the marsh. However, this price must be considered a lower-bound estimate for the value of the marsh because other benefits might remain unaccounted for, the full economic potential of the area might not yet be developed, and consumers might be willing to pay more than the calculated cost to keep the marsh and its associated functions viable.

"Output valuation" measures the value of an output by comparing market-based values of close substitutes (Flowerdew, 1972). For example, the costs of noise pollution in the vicinity of an airport can be estimated by comparing the market prices of properties in the area with those of other properties which are similar in all meaningful respects but are not subjected to aircraft noise (see Table 3.1). A major difficulty with this technique is that few properties are sufficiently similar to ensure that price differentials are due to the externality alone. In addition, many environmental costs (such as the loss of ecological values) are not sufficiently understood or appreciated by consumers to affect the price they are willing to pay for an affected property.

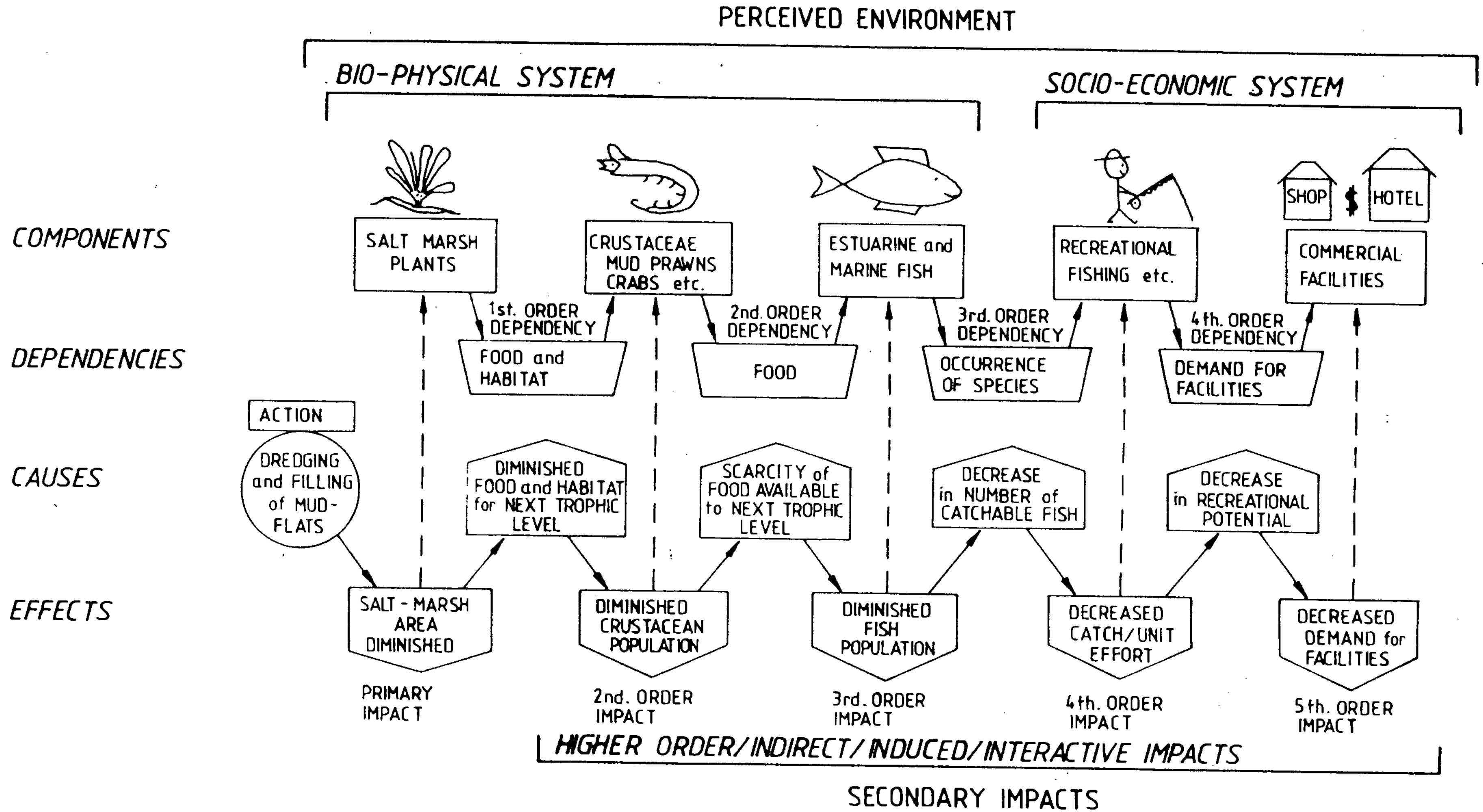
TABLE 3.1
Output Valuation

RELATIVE PRICES OF HOMES

(Comparable homes and neighbourhoods)

Quiet Area	vs	Area near Airport
R 80 000		R 60 000
R 65 000		R 50 000
R 55 000		R 45 000
R 40 000		R 35 000

"Travel-cost valuation" measures the costs of travel and time to utilize some good, such as a recreational facility (Farber, 1988). Users are presumably receiving benefits at least equal to the transportation and other costs incurred to reach and make use of the good. In fact, given certain assumptions, the true value to users (or their total willingness to pay for these benefits, if they were marketable) can be calculated. Among the assumptions required are that the most distant users are not significantly different from other users (i.e., have similar value systems, ability to pay, etc.), that travel time is always a cost, and that the sole object of the recorded expenditure is



TRACING THE SECONDARY IMPACTS WHICH COULD ARISE FROM THE DREDGING AND FILLING OF AN ESTUARINE MUD-FLAT

FIGURE 3.1 **Input Valuation**

to utilize the good being evaluated. Given these assumptions, survey data can be used to construct a complete demand curve for the resource by simulating the effect of a range of admission charges on the visitation rate for groups residing at different distances from the resource (see Table 3.2). These assumptions may not always be true; in addition, the technique can be costly to apply if a high level of confidence in the results is desired, and the technique is limited to situations in which travel costs are a major factor in realizing the utility of a good.

TABLE 3.2
Travel-Cost Valuation

1 ZONE	2 POPULATION	3 ACCESS COST PER VISIT	4 NUMBER OF VISITORS	5 VISITS PER 1000 POPULATION
1	1 000	R1	500	500
2	4 000	R3	1 200	300
3	10 000	R5	1 000	100

"Contingent valuation" uses questionnaires (see Box 3.2) or bidding games to establish a hypothetical market and measure people's expressed willingness to pay for or sell a good (Sinden and Worrell, 1979). Although careful questionnaire design and interviewer training can induce the respondents to think in terms simulating market behaviour, time and information constraints can weaken respondent motivation and some people will deliberately or unconsciously distort their true preferences. People find it difficult to attach monetary values to goods which are not priced in markets, and they may find it unrealistic to think of being compensated for giving up some common property resource. There is also a tendency for people to understate their valuation of a good if they suspect they may actually have to pay for the good, or to overstate their valuation if they think they can be "free riders". In some cases, the appropriate measure of valuation will be one's "willingness to sell" (Mishan, 1981), i.e., the amount one would accept in compensation for bearing a cost or giving up a good, but people will be inclined to overstate their valuation in such cases because there is no budget constraint. In spite of these difficulties, many variations of this general approach to shadow pricing have been developed. Whereas the other approaches are relatively complex and expensive to apply successfully, more limited in the kinds of resource allocation problems to which they may be applied, and generally provide a minimum estimate for the value of a good, this is a relatively simple, straightforward and widely applicable technique for estimating the total perceived value of an externality, or for correcting market values.

Threshold Valuation

A major limitation to the use of shadow-pricing techniques is that people may not be sufficiently knowledgeable or experienced to value many potentially significant external effects, such as costs or benefits associated with ecological processes, the advancement of science and education, and maintaining recreational experiences associated with wilderness settings. For most major resource allocation problems, the nonmonetizable and unquantifiable variables are numerous and not amenable to precise valuation at a reasonable cost. In such cases, shadow pricing may be regarded as impractical, or shadow prices may be suspect, or both.

But very often one does not need to know the estimated value of an output, only whether the value exceeds a certain amount; this constitutes calculating a threshold value, or "*contingency price*", for external effects rather than finding shadow prices for them (Sinden and Worrell, 1979). Rather than ask what several extra-market goods are worth, one asks whether they are worth more or less than a certain amount; this type of judgment is much easier to make. One in effect searches for a point of equivalency between incommensurables, and is concerned with identifying the threshold of value where the one output just outweighs the other. Since one output is valued in monetary terms, this threshold represents a contingency price for the other output.

BOX 3.2
Contingent Valuation: Excerpt from Questionnaire Used for Groenrivier Survey (Case Study 1)

7. Please indicate on the enclosed map where you live.
8. So that researchers can calculate the average cost of recreational visits to the coast, please list all your party's expenses for this visit to Groenrivier mouth.
   (a) Food and drink: R____
   (b) Petrol: R ______
   (c) Other items which will be consumed (such as paraffin, gas, fishing bait, etc.): (PLEASE SPECIFY EACH ITEM)
   ITEM: ____________ COST: R ________
   ____________ ________
   ____________ ________
   (d) Items of special equipment that was purchased because needed for this visit. (PLEASE SPECIFY EACH ITEM)
   ITEM: ____________ COST: R ________
   ____________ ________
   ____________ ________

9. You obviously feel that the cost of this visit is reasonable or you wouldn't be here. But what if the cost of making these trips were to go up? For example, if the price of petrol were to increase dramatically, or other expenses were incurred, there must be some point where you would decide it's not worthwhile coming here anymore. If you think carefully about it, how much more money do you feel your party would have been willing to spend before deciding against making this trip.

/_/ R1 - R5; /_/ R6 - R10; /_/ R11 - R20; /_/ R21 - R30;

/_/ R31 - R50; /_/ R51 - R100; /_/ R101 - R200; /_/ R201 - R500

/_/ R501 - R900; /_/ R900 plus

For example, if there is a proposal to develop a wetland site that is used by an endangered species of waterfowl, and a Cost-benefit Analysis reveals that the excess monetary value of development over preservation is R50,000, the decision maker might conclude that the value of the contribution that the site makes to the preservation of endangered waterfowl is greater than R50,000. In this case it has not been necessary to determine the value of the site's contribution to the preservation of endangered species, but simply to judge whether that value would exceed R50,000 or not.

A contingency price, then, is the amount of money required to equalize the excess monetary benefit of one alternative over another. Threshold valuation is an analytical procedure rather than a shadow-pricing technique. The object is not to estimate the value of an output, but to calculate what its value would have to be to change the decision. The nonmonetary costs of an action are simply listed and their aggregate value is compared with the net monetary benefits of that action. This focuses attention on what the real trade-off is, and can be a fruitful approach to analyzing many resource allocation problems.

The major difficulty with threshold valuation is that there are often several nonmonetizable impacts to evaluate against the present discounted value of a proposal. This means the decision maker has to conceptualize and weigh the significance of several outcomes, and then compare the combined valuation of these outcomes to a single (usually large) sum of money (the value of which must also be conceptualized accurately so that a fair comparison can be made). This problem is commonly encountered when the resource allocation decision is complex and controversial, and is particularly serious when there are insufficient resources to employ shadow-pricing techniques to reduce the area of uncertainty in making comparative evaluations, or when there is a relatively unsophisticated decision making environment. This is the situation that obtains in South Africa, where there is limited expertise for conducting shadow-pricing, limited funds for financing such investigations, and considerable skepticism about the validity and usefulness of shadow prices.

Dynamic Opportunity Cost Valuation

Krutilla and his associates have developed another approach to evaluating losses of irreplaceable environmental services (Krutilla *et al.*, 1972). This approach is based on the assumption that it is not reasonable to assess the value of some environmental services simply in terms of today's supply and demand situation. This includes those ecological functions and natural amenities which are capable of producing potentially significant benefits in perpetuity, but which can also be destroyed by overuse, cannot be replaced once lost, and appear to have no satisfactory substitutes. Examples are recreation opportunities afforded by wild and scenic rivers, and the screening of ultraviolet radiation by the ozone layer (Krutilla and Cicchetti, 1972; Fisher and Krutilla, 1985).

For resources that fall into this category, one needs to take into account their increasing scarcity value over time, since demand may be expected to increase dramatically with population growth and higher standards of living. Since these resources cannot be created on demand, actions which reduce their availability have a "*dynamic opportunity cost*": a cost which grows over time. And since technological progress may be expected to reduce the scarcity value of many producible goods which are now in competition with these irreproducible goods, whereas the scarcity value of the latter may be expected to increase, the conventional present discounted value calculation may not be a good measure of efficiency - even from the point of view of the present population. And from the point of view of future generations, the potential for a misallocation of resources is even greater.

The approach Krutilla has taken to estimating the present discounted value of these goods is to project various rates at which $1 worth of goods today might be expected to increase, given certain assumptions based on prevailing conditions and trends. For example, given the historic correlation between rising socioeconomic status and preferences for outdoor recreation, projected increases in affluence and mobility might be expected to result in an increase in demand for outdoor recreation opportunities relative to other goods. Since technological innovation cannot reasonably be expected to increase the availability of environmental services and conditions needed to provide these opportunities, the relative value of these goods may be expected to increase over time. Unfortunately the rate of increase is extremely difficult to forecast. The determinants of future demand are complex, particularly over longer time horizons: changes in relative value will depend on future tastes and preferences, environmental conditions and rates of technological advance. Krutilla therefore advocates presenting decision makers with a range of forecasts for each key determinant spanning all estimates that seem to be in the realm of possibility. (Box 3.3 presents an example of how a variation of Krutilla's approach was applied in one of the case studies.)

Dynamic opportunity cost valuation is a logical extension of threshold valuation but depends on the acceptability of assumptions (regarding rates of progress in technological advance, and rates of change in future preferences) which may not be readily understood or embraced by many decision makers or the general public. It is also dependent on the availability of monetary values (whether market prices or shadow prices, or some combination thereof) to establish present valuations for making projections, and cannot incorporate factors for which such values cannot be determined.

X

BOX 3.3

Changes in Relative Values of Preservation and Development Benefits Due to Anticipated Growth in Demand for Preservation (based on a model developed by Krutilla *et al.*, 1972)

Development projects have a dynamic opportunity cost if the relative value of preservation benefits are expected to grow over time. The following table illustrates various values for the initial year's preservation benefits which would be required to exceed the present value of nature area project costs plus (foregone) net marina development benefits if different assumptions are made regarding the appropriate discount rate and changes in the relative value of preservation benefits. For example, if the discount rate is 3%, and the rate of price growth for preservation benefits increases 2% per annum while the quantity demanded at the given price increases 4% per annum, then the present value of one Rand's worth of initial year's preservation benefits is R113.13. Since the present value of nature area project costs and net marina development benefits, discounted at 3%, is R39.6m, the initial year's preservation benefits must be worth at least R350 000 for the nature area to be preferred over the marina.

I =	DISCOUNT RATE
R =	RATE OF PRICE GROWTH (HORIZONTAL DEMAND SHIFT)
G =	RATE OF GROWTH IN QUANTITY DEMANDED (VERTICAL DEMAND SHIFT)
PVP =	DISCOUNTED PRESENT VALUE OF ONE RAND'S WORTH OF PRESERVATION BENEFITS
PVD =	DISCOUNTED PRESENT VALUE OF NATURE AREA COSTS AND NET MARINA DEVELOPMENT BENEFITS
BPI =	INITIAL YEARS PRESERVATION BENEFITS REQUIRED TO EQUAL VALUE OF MARINA DEVELOPMENT

TIME HORIZONS : NATURE AREA 50 YEARS
MARINA PROJECT 50 YEARS

	R	G	PVP (Rands)	PVD (million-R)	BPI (thousand-R)
I = .030					
	.010	.000	31.55	39.6	1255
	.010	.010	39.38	39.6	1006
	.010	.020	50.00	39.6	792
	.010	.040	84.83	39.6	66
	.010	.060	152.99	39.6	58
	.020	.000	39.38	39.6	1006
	.020	.010	50.00	39.6	792
	.020	.020	64.59	39.6	613
	.020	.040	113.13	39.6	350
	.020	.060	209.49	39.6	189
I = .060					
	.010	.000	18.40	24.3	1319
	.010	.010	21.77	24.3	1114
	.010	.020	26.16	24.3	927
	.010	.040	39.63	24.3	612
	.010	.060	64.11	24.3	378
	.020	.000	21.77	24.3	1114
	.020	.010	26.16	24.3	927
	.020	.020	31.94	24.3	759
	.020	.040	50.00	24.3	485
	.020	.060	83.50	24.3	290

While dynamic opportunity cost valuation and other techniques have served to assist the decision maker in making comparative evaluations of competing resource allocation proposals, there are still many situations in which the aggregate value of several important outputs cannot be estimated in monetary terms. There is therefore a great need to develop an acceptable technique for measuring outputs in nonmonetary terms but using a scale that permits the aggregation of values. The next section discusses the principles of measurement theory, and explores different approaches to scaling items that might lead to the development of a useful measuring rod for determining the relative value of all unpriced impacts that could be associated with any resource allocation proposal.

MEASUREMENT THEORY

The central problem posed in this dissertation is how to determine which of two or more controversial and mutually-exclusive resource allocation proposals is in the best overall interests of society. The resolution of this problem requires the adoption of suitable techniques for measuring different kinds of data. In order to rank environmental situations on a scale of better or worse, it is necessary to first find a way of placing meaningful values on the various outcomes associated with the alternatives, and this must be done in a way that is appropriate to the situation at hand (i.e., depending on the importance of the decision and the resources available for measuring the data).

Two very different types of measurement problems are involved. The ultimate measurement problem is to rank-order the proposals by the selected criteria (see Defining Evaluation Criteria in Chapter 4). But in order to accomplish and justify this rank-ordering, an important intermediate measurement problem must be addressed: the relative value or utility of all the outputs associated with each alternative must be judged so that their combined effect can be compared. Human values are essentially subjective and so the difficulty is in establishing a subjective metric that will bring all the costs and benefits of each alternative under a common measuring rod (Thurstone, 1954). This subjective unit of measurement must be deemed sufficiently accurate to serve as a guide for making the necessary measurements, comparisons and trade-offs. Therefore another field of study that is relevant to the topic of this dissertation is that concerned with obtaining reliable and valid measurements of data sets.

In what follows the general concept of measurement will first be discussed, then the various scales of measurement will be presented, and finally several methods of measurement will be explored.

The Nature of Measurement

According to Green and Tull (1978), measurement is concerned with the correspondence between empirical entities and a formal model consisting of abstract elements (*e.g.*, numbers), the relations among these elements, and the operations that can be performed on them. Coombs *et al.* (1970) state that the subject matter of measurement theory is the delineation of the various types of measurement and the explication of their meaning. The goal of measurement theory is to analyze the measurement process, and determine the appropriateness of various measurement procedures and the meaningfulness of their results.

According to Coombs *et al.* (1970), the basic problems of measurement theory are

- The <u>representation</u> problem: if not all attributes can be measured, what conditions are required for the construction of a measurement scale?

- The <u>uniqueness</u> problem: for a given measurement procedure, how much freedom is there in assigning numbers to objects?

- The <u>meaningfulness</u> problem: what assertions can be meaningfully made on the basis of a numerical measurement scale?

- The scaling problem: how can we construct numerical scales and convert ordinal information into statements about numbers?

  Following is a brief discussion of each of these problems (based on Coombs *et al.*, 1970).

Representation

A numerical system is regarded as a model of the world if it reflects the structure of the world or represents its essential features. Because measurement is numerical representation of an empirical relational system by a formal relational system, it is essential that the relations among the objects of the world be properly reflected by the relations among the numbers assigned to them.

Uniqueness

Given that there is a correspondence between numbers and some empirical relational system, there is then the question as to how much freedom we have in constructing a scale and to characterize the relationships among the data. This concern has to do with admissible transformations of scale values - *e.g.*, to meet the requirements of an ordinal scale, transformations need only be order preserving, but to meet the requirements of an interval scale, transformations must be difference preserving.

Meaningfulness

In some cases no objective meaning can be given to the uniqueness problem, but a statement involving numerical values is formally meaningful if its truth (or falsity) is invariant under all admissible transformations of the scale values. An example is the IQ scale, which is widely regarded as providing a useful and highly informative index even though no measurement theory for intelligence is available. In this case, even though the uniqueness problem is not well defined (because of the absence of a well-defined representational relation), measurement can still be regarded as valid and meaningful, provided that subjects can follow instructions in a consistent and unbiased fashion.

This important proviso or assumption has testable consequences, and tests are needed to validate a measurement procedure. For example, if X is felt to be twice as heavy as Y, which in turn is felt to be three times as heavy as Z, then according to the ratio estimation procedure, X should be felt to be six times as heavy as Z. Hence, although numbers can be properly assigned to objects even in the absence of a well-defined measurement model, the meaningfulness of the results depends on the validity of the underlying assumptions.

Scaling

Scaling is the process of assigning numbers to objects or properties. A central concern of measurement theory is establishing the conditions under which various types of scales can be constructed. Rarely are measurement models satisfied exactly, and the purpose of measurement is to provide a satisfactory relationship between numbers and entities (Alchian, 1953). There are many different conditions under which measurement may be considered desirable and appropriate, and there are several different ways to measure data, according to the nature of the data and the problem at hand.

Even if validity and precision cannot be assured, it may be better to measure than not to measure. The challenge is to find a scaling method that removes error from "noisy" data and provides means of estimating the "true" scale values. For example, if one assumes the existence of a universal set of human values ("true scale values") that differ in significance or importance, it seems reasonable to expect that there would be considerable error in each individual's measurement of these values due to imperfections in perception ("noisy data"); then the problem is to find some scaling method that provides the closest approximation of the true scale values.

Scales have the potential to greatly facilitate our understanding of both objective and subjective data, even when measurement is imperfect. Stevens (1951) has pointed out that when this correspondence between the formal model and its empirical counterpart is close and tight, we find ourselves able to discover truths about matters of fact by examining the model itself. And in the absence of other ways of obtaining and organizing data pertaining to the empirical relations among objects and events (such as, for example, the significance of outcomes from given acts), the numerical model may be the most reliable way we have to understand and express these relations.

Primary Types of Measurement Scales

There are four major categories of measurement scales, and each scale possesses its own set of underlying assumptions regarding the correspondence of numbers with real world entities. These correspondences progress as knowledge about phenomena increases. Each of the four scales of measurement is best characterized by its range of invariance - by the kinds of transformations that leave the "structure" of the scale undistorted (Stevens, 1951). The four relations which are associated with and distinguish the four scales are equality (nominal scale), rank order (ordinal scale), equality of intervals (interval scale), and equality of ratios (ratio scale).

Following is a brief discussion of the characteristics of these four scales (based on Green and Tull, 1978).

Nominal Scales

Nominal scales assume the least knowledge about correspondences between the abstract elements and the empirical entities. In this type of scale the numbers serve only as labels for identifying the entities of interest. Examples are numbers assigned to participants in a sporting contest, or numbers that identify a particular telephone exchange or subscriber. Nominal scales permit only the most rudimentary of mathematical operations, such as counting the number of members of each telephone exchange class and finding the modal or most numerous class.

Ordinal Scales

Ordinal scales assume the ability to rank entities according to some attribute. In this type of scale the numbers serve to identify the order in which different entities are perceived to display or feature a particular attribute. It is therefore assumed that it is possible to distinguish whether one entity has more or less of the attribute than does another, but there is no presumption that the magnitude of the differences between the entities in terms of this attribute can be perceived. For example, a person may be able to rank a selection of scenic vistas for their aesthetic appeal without being able to say whether the difference between the aesthetic value of the first- and second-ranked scenic vistas is greater than that of the second- and third-ranked scenic vistas. Ordinal scales allow statistical descriptions concerning positional characteristics, such as median, quartile, and percentile or other summary statistics that deal with order among entities, but the usual arithmetical operations cannot be meaningfully interpreted with ranked data.

Interval Scales

These scales possess a constant unit of measurement which makes it possible to make meaningful statements about how much entities differ in terms of some attribute. Nevertheless, this type of scale does not have a true zero point; that is, the zero point on this scale is arbitrary. For example, both the Fahrenheit and centigrade scales measure temperature in a way that expresses the differences between any two states of "warmness" or "coldness", but both use a zero point that is not related to an absolute condition (i.e., absence of temperature, or absolute zero). This means that although certain mathematical operations can be meaningfully performed on the data, it is not possible to say that any value on a specific scale is a multiple of another. For example, 50 degrees Fahrenheit is not "twice as warm" as 25 degrees Fahrenheit. Nevertheless, the differences between values on a temperature scale are multiples of each other. That is, the difference between 50 degrees Fahrenheit and 0 degrees Fahrenheit is twice the difference between 25 degrees Fahrenheit and 0 degrees Fahrenheit. Most ordinary statistical measures, such as arithmetic mean, standard deviation, and correlation coefficient, require only interval scales for their computation. But some statistical measures, such as the geometric mean and coefficient of variation, cannot be applied to interval scaled data.

Ratio Scales

These scales possess a unique zero point and therefore all arithmetic operations are permissible on ratio scale measurements. Ratio scales, which are commonly associated with (and very important to) the physical sciences, allow one to move from one scale to another by applying an appropriate positive multiplicative constant because equal ratios among the scale values correspond to equal ratios among the entities being measured. For example, 3 yards is 3 times 1 yard, and 9 feet and 3 feet are in the same ratio, *viz.*, 3:1. A ratio scale contains all the information (class, order, equality of differences) of lower-order scales and more besides, so that all statistical computations can be performed on ratio scales.

Extensions of Scale Types

Measurement theorists have found ways of extending the primary scales discussed above. One development of particular importance to psychological scaling is the application of what are known as ordered metric scales. These scales are concerned with ordering points along a continuum, and then ordering intervals separating adjacent points (see Box 3.4). A first-ordered metric is one in which adjacent intervals can be ordered. But if the intervals between each pair of points can be ordered, then one obtains a higher-ordered metric (or "ordered metric") which conveys much more information than the simple ordinal scale. In fact, by adding more and more points on the continuum separating the end points, it is possible to eventually obtain an interval scale. Ordered metric scales are important to various nonmetric approaches to multidimensional scaling and multivariate analysis (Green and Tull, 1978).

BOX 3.4
Constructing Ordered Metric Scales
(from Green and Tull, 1978)

Assume that we have ordered five points, A, B, C, D, and E, along a continuum and, furthermore, that we can order *intervals* separating adjacent points as:

$\overline{AB} < \overline{BC} < \overline{DE} < \overline{CD}$

where the "bar" denotes "distance" between a specific pair of points. The representation below would satisfy these inequalities.

A B C   D   E

Methods of Scaling Data

A number of methods have been developed for scaling data, as well as several variations of some of the basic methods. These methods are sometimes called by different names, and different classification systems have been developed (see, for example: Baird and Noma, 1978; Green and Tull, 1978; Guilford, 1954; Stevens, 1957; Thurstone and Jones, 1959; Torgerson, 1958). Green and Tull (1978) have identified two general types of methods for scaling data: variability methods and quantitative-judgment methods. The former yield ordinal measurements, while the latter yield interval or ratio measurements.

Variability Methods

These methods assume the basic data can only be ordinal-scaled. They include paired comparison, ranking, ordered-category sorting, and rating methods.

- The *paired-comparison method* involves dividing the data into every possible combination of pairs, and then comparing each pair of items in terms of the attribute of interest and deciding which item of each pair ranks higher. This method is time-consuming and produces inconsistencies (i.e., intransitive judgments).

- The *ranking method* involves a straightforward ordering of the entire list of items. This method is faster than paired comparison, but can be difficult to apply if there is a long list of items to be ranked; this method can also force consistencies when there may be genuine cases of intransitivity.

- The *ordered-category sorting method* involves the ranking of groups of items, which can then be further ordered using other techniques. This method is useful for dealing with large numbers of items, but is based on the assumption that all items within a given category hold the same rank-order relationship with all items within another category.

- The *rating method* involves assigning a number (*e.g.*, from 1 to 5), or a quality (*e.g.*, very dull, dull, neutral, bright, very bright) to each item which expresses the degree to which it possess the attribute of interest. This method is easy to apply and can provide an ordering in numerical, graphic or verbal terms (or a combination of these).

Quantitative-Judgment Methods

These methods are concerned with expressing the difference between items in terms of the attribute of interest. They include direct-judgment, fractionation, constant sum and scaling model methods.

- The *direct-judgment method* involves rating items on some scale which emphasizes subjective distance relative to other items. The problem with measuring subjective distance is that the subjective origins of respondents, and the scale units used by respondents, may differ from each other or at different times (even during a single series of measurements).

- The *fractionation method* involves asking respondents to give a numerical estimate of the ratio between two items with respect to the attribute of concern. This can be repeated, comparing all items to some standard item. The problem of subjectivity (the tendency of respondents to scale from different points of origin and use different scale units) also applies to this method.

- The *constant sum method* involves distributing some number of points over the items to show their relative value in terms of the attribute of interest. This provides a subjective ratio score between each pair of items based on uniform scale units, but the absence of an objective point of origin means that the values assigned by different respondents may have widely divergent meanings. For example, it is conceivable that two respondents could give identical scores to each item (say 20 points to each of 5 items) when one respondent regarded all the items as having great value and the other respondent regarded all the items as having very little value.

- The *scaling model method* involves transforming raw data that are ordinal-scaled (from one of the variability methods) into a set of scale values that are interval-scaled. For example, Thurstone's Case V Scaling Model is based on an analysis of numbers of observations as to whether one thing is preferred to another; the modal discriminal process yields a particular response more often than others. The scale difference between the modal discriminal processes for any two stimuli is called the discriminal difference, and it is assumed that the discriminal differences between pairs of stimuli are normally distributed (it is also assumed that the mean = median = mode). This allows the calculation of standard unit variates called "Z values" that are associated with a given proportion of the total area under a normal curve, so that an interval scale may be derived from an ordinal scale through statistical analysis (Green and Tull, 1978).

These methods of scaling data suggest several approaches that might be taken to the problems of (1) measuring the relative significance of unpriced impacts and (2) rank-ordering alternative proposals by a set of specified evaluation criteria. For example, Stevens (1951) claims that there is persuasive evidence to attest the empirical validity and reliability of the judgment of ratios. Direct scaling procedures have been applied in several areas of behavioural science, and this research indicates that the typical observer has an extraordinary ability to make direct magnitude matches on one continuum to the same aspect on another (Stevens, 1975:230). This simple and direct kind of measurement has been applied not only to the quantification of sensory magnitudes, but also to other interesting matters concerned with human judgment. Examples are the prestige of different occupations, the seriousness of different crimes, preference for wristwatches, the aesthetic value of handwriting, and the importance of Swedish monarchs (Stevens, 1975).

Ratio estimation procedures have led to consensus in judgments for a wide variety of metric and nonmetric stimuli, but the question is whether such results can be regarded as valid. Stevens (1975:266-267) has adduced evidence that they can:

> For both kinds of continua - those based on metric stimuli and those based on nonmetric stimuli - we find a constant relation between the scale erected by direct judgment and the poikilitic scale derived from a unitizing of variability or confusion. Whether the stimuli themselves are measurable on ratio scales or only on nominal scales, the judgmental scale based on units of variability is approximately proportional to the logarithm of the scale constructed by one or another of the direct scaling methods, such as magnitude estimation. The extensive invariance of that logarithmic relation attests to a principle known throughout all of science - namely, that error or variability tends to be *relative*: the size of the error grows with the magnitude of the thing measured. . . . The emergence of a similar rule in the subjective domain - a rule that variability tends to increase in proportion to the apparent magnitude - suggests an essential unity among the principles that govern quantitative relations in widely diverse endeavors. . . . For those who must build their science on a consensus based on one or another expression of human judgment, the way stands open for an effective ratio-scale quantification . . . the foundations of social psychophysics have been set in place.

The next chapter discusses one approach to scaling data, as well as other possible applications of measurement theory, economic theory, and decision theory in the development of an environmental evaluation methodology for improving resource allocation decisions.

DISCUSSION

This chapter has presented a discussion of several concepts discovered in the literature which are considered to provide a suitable foundation for the development of an environmental evaluation methodology. The literature on decision making, economics, and measurement have provided the major theoretical constructs for the development and testing of an evaluation methodology, and in particular for devising a formal method of evaluation which can aid decision making when proposals are especially controversial.

Decision making necessarily entails some evaluation of the possible outcomes of alternative proposals. Because in the case of controversial resource allocation proposals the evaluation problem is usually very complex, and there is likely to be considerable disagreement as to the relative importance of specific evaluation criteria, a special effort should be made in such cases to ensure that the decision is guided by procedures which are both rational and systematic. A major question, therefore, is how to best apply and trade-off the criteria. Several alternative approaches to decision making were discovered.

First there is a need to follow a general procedure which is based on principles of political rationality, in order to guide planning, assessment and evaluation. But if there remains serious dispute between major concerned parties, there is also a need to make provision for a specific procedure (a formal method of evaluation), which is based on principles of economic rationality, in order to identify which proposal is superior. While "satisficing" may be the most practical approach to making most resource allocation decisions, there are cases when the importance of the resources and the intensity of the conflict may warrant application of the "maximizing" approach.

While Decision Analysis has given rise to a number of approaches for making decisions involving multiple criteria, most of these are relatively sophisticated, time-consuming and costly. In addition, such methods are designed to be employed by the decision maker himself, rather than by groups of individuals whose combined knowledge, expertise and insight might be expected to provide more acceptable judgments. Conflict situations are characterized by misunderstanding and mistrust; therefore, a group evaluation procedure based on behavioural interaction is likely to have greater credibility than an evaluation procedure which utilizes the value judgments of only one person.

There is thus a need for a relatively simply and straightforward approach to obtaining group thinking on how to make a decision involving multiple criteria. Group evaluation procedures such as Delphi and the Nominal Group Technique can bring a greater body of information and experience to the evaluation, and reduce the real or imagined effects of partiality and narrow self-interest. These two approaches therefore provide promising models for the development of a method for evaluating controversial resource allocation proposals.

The principles and concepts of economics (and particularly the emerging discipline of environmental economics) can provide a sound theoretical foundation on which a rational philosophy of resource management could be based, including formulating the goal of resource allocation and the criteria for evaluating resource allocation proposals. Cost-benefit Analysis provides a promising framework for evaluating controversial resource allocation proposals, but it has been essentially limited to applying the efficiency criterion and has been criticized for failing to properly evaluate "unpriced" costs and benefits. But the theory underpinning Cost-benefit Analysis could provide a major part of the rationale for the general evaluation methodology, and the cost-benefit framework could provide the basic model for a suitable method of formal evaluation. In addition, various shadow-pricing techniques and other approaches to evaluation associated with Cost-benefit Analysis and environmental economics could be important adjuncts of a formal method of evaluation.

Although advances in shadow-pricing and other techniques have partially overcome the problem or evaluating nonmarket goods, it is not always practical or acceptable (especially in Third World situations) to apply these techniques, and in any case there are often major costs and benefits which remain completely nonmonetizable. The big problem is how to measure or otherwise take account of nonmonetizable costs and benefits.

The literature dealing with measurement and scaling was essential to developing an understanding of the problem of evaluating outcomes which cannot be objectively quantified or expressed in commensurate units. Several techniques were reviewed which suggest different possible approaches to the very difficult problem of valuation, which is the principal subject of this dissertation: judging the relative significance of unpriced impacts from resource allocation activities. Measurement theory provides characteristics of different scales which may be used to organize and mathematically manipulate data, and several scaling techniques have been developed which could provide the basis for developing a practical and reliable approach to estimating the relative significance of nonmonetizable impacts. There are two major difficulties in undertaking group evaluations of nonmonetizable costs and benefits. First, each individual must apply some acceptable procedure for measuring the relative value of each cost and benefit. Then the values assigned to each cost and benefit by several individuals must be aggregated to yield a group measure of the net benefit associated with a proposal. In order to do this, however, individual valuations must be scaled from a common point of origin and expressed in uniform scale units, and this must be done in a way that is not unduly distorting, and that will be acceptable to the concerned parties. This task is the central challenge which must be addressed if one is to apply a group evaluation procedure within a cost-benefit framework.

CHAPTER 4

THE DEVELOPMENT OF A RESOURCE MANAGEMENT STRATEGY AND AN ENVIRONMENTAL EVALUATION METHODOLOGY

OVERVIEW

This chapter is concerned with exploring issues that are particularly relevant to the central problem of how to allocate resources, and to bring certain fundamental concepts into a unified theoretical basis for the development of a suitable environmental evaluation methodology.

A comprehensive approach to resource management involves both strategic considerations - to provide general guidance for managing the national resource base - and methodological considerations - to provide guidance for making specific resource allocation decisions. Accordingly, the resource management problem is addressed at two levels. On one level, certain principles, policies and procedures are presented which serve to define a broad management strategy. On the second level, an evaluation methodology is presented to aid in the implementation of this strategy, and to provide the value information that is needed to choose between resource allocation proposals.

The management strategy and evaluation methodology have been designed to meet the requirements of the present situation in South Africa. Because environmental evaluation has not heretofore played a large role in resource management in South Africa, and expertise and other resources are in short supply, the research emphasis was on developing relatively simple and cost-effective methods and techniques for accomplishing both formal and informal environmental evaluations.

The chapter begins by formally identifying the <u>goal, objectives and evaluation criteria</u> that have been adopted to guide resource allocation decisions. The evaluation criteria are then used to devise a general <u>strategy</u> for managing the resource base. Attention then turns to the development of a research <u>methodology</u> for evaluating competing resource allocation proposals. The major focus of the chapter, however, is on identifying the requirements of a specific <u>method</u> of formal evaluation that can be applied to especially controversial resource allocation proposals.

It was decided to adopt a cost-benefit framework in developing a formal method of evaluation because there appears to be no other practical solution to the methodological problems of valuation (Pearce, 1983). There is a brief discussion of the issues that arise from a decision to give Cost-benefit Analysis a major role, and how these issues will be addressed.

Then two further questions are addressed that must be answered before the formal evaluation method can be developed:

- Who will do the evaluating?
- What evaluation techniques will be acceptable to all potentially concerned parties?

These questions are answered in terms of the previously specified principles underpinning a research methodology for environmental evaluation, as well as in terms of the issues that have been raised in conjunction with Cost-benefit Analysis. It is concluded that a group evaluation method is more likely to be acceptable to all concerned parties in a resource allocation dispute, and is also more likely to identify the proposal that is actually in the best interests of society. Following a discussion of the advantages of group evaluation techniques, there is a decision to base the evaluation method on Delphi concepts.

Next there is an examination of the fundamental problem of measuring unpriced impacts, and a proposed solution to the problem is advanced. Finally, a set of procedures which constitute a formal evaluation method is briefly described, and then two case studies are presented which illustrate somewhat different variations and applications of the method. The chapter concludes with a critique of these case studies, and a discussion of the need to develop new procedures for three of the critical evaluation tasks.

DEFINING EVALUATION CRITERIA

Biswas and Geping (1987:191) have stated that environmental concerns in developing countries are marked by a determination to achieve sustainable development in an environmentally-sound manner. But beneath this disarmingly simple and clear statement lurk great complexities and difficulties. The pursuit of environmentally-sound, sustainable development poses one of the great global challenges of the coming decades. In order to develop a practical guide to action, the challenge needs to be operationally defined, and specific goals, objectives and evaluation criteria need to be formulated. This will then provide direction for the development of sound resource allocation strategies and environmental evaluation procedures.

The social welfare function in economic theory can be reformulated to embrace such ideas as achieving sustainable development and maintaining environmental quality. According to Pearce (1986:394), the social welfare function is a statement of a society's objectives in which the level of social welfare or well-being is represented as a function of the way in which resources are allocated.

> In defining social welfare we face two sets of problems. The first problem concerns the "social aspect". In general, social welfare is seen as some aggregation of the welfare of individual members of a society - this raises the question of how the aggregation is to be achieved. The second problem relates to the concept of "welfare". I.M.D. Little has argued . . . that "welfare" is an ethical concept since to define something as contributing to welfare is to make a value judgment about whether that thing is good or bad . . . definitions of social welfare are usually regarded as value judgments.

A social welfare function is equivalent to a decision rule or "constitution", *i.e.* a set of rules for transforming the opinions and desires of the members of a society into concrete choices made from the alternatives which are available to that society (Bannock, *et al.*, 1978:415). Although one school of thought argues that Arrow's "Impossibility Theorem" has rendered the concept of a social welfare function inoperable, another school argues that some of Arrow's requirements are not reasonable and that it is possible to work with any "given" social welfare function without being directly concerned with the process of formation (Bannock, *et al.*, 1978:416; Pearce, 1986:394). Herfindahl and Kneese (1974:388) have suggested that if the theorist feels that there are defects in the process by which society determines courses of action, he may want to abandon his role as observer and try to specify those aspects of the social welfare function that ought to be adopted by society.

Resource allocation decisions can be improved, and controversies surrounding resource allocation proposals can be resolved (or greatly reduced) if all concerned parties can agree on the adoption of a form of the social welfare function and an approach to evaluation that will result in a ranking of alternative environmental situations (to include both biophysical and socioeconomic considerations) on a scale of better or worse. Before such an approach can be developed, however, it is necessary to clearly establish what evaluation criteria are relevant and to formally define these criteria. And by the same token, before evaluation criteria can be formulated, the goal of resource allocation must be formally defined. If this goal is to be universally accepted, it must be derived from a reasonable set of premises. The following discussion is directed at developing an acceptable form of the social welfare function that is relevant to contemporary social and environmental circumstances (particularly in a Third World context). Specifically, the discussion is intended to clarify the premises on which the goal of resource allocation is based, the objectives of resource allocation that are derived from the premises and goal statement, and the evaluation criteria that are related to the objectives.

Premises

The resource allocation strategy and environmental evaluation methodology that have been developed during the course of this study are ultimately grounded on the following premises (Dohan, 1977; Herfindahl and Kneese, 1974; Lipsey, 1979; Lutz and Lux, 1979; Maler, 1985; Mishan, 1981; Page, 1977).

- Resource allocation decisions are solely concerned with improving social well-being; *i.e.*, we can reject any value system concerned with maximizing variables independent of their relationship to human welfare (Dohan, 1977:134). This means that impacts on other species and on natural systems are only relevant insofar as these affect mankind.

- Every improvement in social well-being is achieved at some "opportunity cost". Opportunity costs are perceptions of something lost or foregone in order to have something else, and can be material or nonmaterial in nature (*e.g.*, clothes, flowers, time, scenic views or energy).

- If a given amount of resource can be made to yield higher net benefits, then society can be made better off.

- A society's well-being is made up of the well-being of those individuals comprising that society.

- A society is comprised of groups of individuals placed differently in time as well as space, and the well-being of these present and future groups will be differently affected by resource allocation decisions.

- The well-being of each individual or group of individuals in society is inherently as important as the well-being of any other individual or group of individuals, and therefore both the intragenerational and intergenerational distribution of costs and benefits are relevant to any evaluation of social well-being.

Of these six premises, perhaps only the first and the last may be considered very controversial. As regards the latter, the goal of resource allocation activity depends on whether one takes a narrow, individual perspective, or a broader, social perspective: the goal of the individual is simply to maximize his own well-being (and that of any groups with which he identifies), while the goal of society is to advance the general welfare, which entails reconciling the competing interests of individuals and groups comprising society. Some individuals are only concerned about themselves and those who are close to them, and feel no real commitment or obligation to other members of society. This stance can be regarded as rational from the individual or group point of view, particularly when other individuals or groups are seen as potentially hostile or remote (in space or time), or when great sacrifices might be expected of one's own group to better the condition of another group (Hardin, 1977a).

But there is no rational or ethical basis for placing the interests of one individual or group over that of any other, and the decision maker who has been entrusted with responsibility for the allocation of society's scarce resources has a logical and moral responsibility to consider and balance the claims of competing groups in order to advance the welfare of society as a whole, and not to use his power to advance his own personal interests or the interests of his particular group. The fact that this is rarely done does not obviate the fact that it should be done, and there are indications that historically recent developments in the economic, social and political

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circumstances of many countries now dictate that it is in the self-interest of the dominant groups in every society to give more attention to the wider social perspective (Wilson, 1978:199).

As regards the first premise, the assumption that resources are to be allocated for the benefit of mankind (and not for other species or aspects of nature), there are many people who feel that the welfare of individual human beings - or even of the entire human race - should be subservient to maintaining the natural order. The debate over whether nature should be saved for man's sake or for nature's sake is complex and revolves around highly personal value judgments based on religious convictions and/or ethical principles deriving largely from individual emotional responses to nature and man (Daly, 1987; Leopold, 1966, 1970; Kneese and Schulze, 1985; Passmore, 1974a, 1974b; Stone, 1974; White, 1967). While it is not possible to say one viewpoint is right and one is wrong, there is a very pragmatic reason for accepting the view that resource allocation decisions are to be directed at improving the welfare of mankind: people who have the responsibility and the power to make resource allocation decisions are almost always motivated to place human interests above the interests of any other part of nature because they are beholden to their constituencies - *i.e.*, they are acting on behalf of and in the interests of societies of men.

In addition, no matter how sympathetic decision makers may be to the idea of protecting nature, they are charged with making marginal decisions to improve social well-being, and the philosophy of saving nature for nature's sake does not provide a practical guide to action for making decisions at the margin (*e.g.*, many of man's actions adversely affect parts of nature in some way; what decision rule can be used to determine which or how much of these actions are acceptable?) Therefore, if the first premise is not accepted, there is no rational basis for guiding human activity: if all nature must be protected, social progress will be impossible; and if some of nature is to be protected, the question is what parts, and how much, and how will these decisions be made? These are not academic arguments - they are important considerations to be addressed if one is to avoid emotional blinkers and formulate an acceptable rationale for making resource allocations decisions.

The proponents of saving nature for nature's sake (most of whom recognize that parts of nature must be sacrificed for human ends) usually advocate this position for one of two reasons: because of their personal preference for nature (and relative lack of concern for humanity), or because they fear that mankind will continue exploiting nature until both collapse together. The first reason - the "elitist argument" - is not really morally or rationally defensible in a country such as South Africa, where large sectors of the population still live in great poverty. But the second reason is more cogent: if resource allocation <u>is</u> only concerned with improving social well-being, and this is always done at the margin (*i.e.*, taking decisions which have a limited context, such as concern with a particular group within a limited geographical area and over a limited time period), then unforseen cumulative or synergistic effects could eventually result in a sudden and disastrous decline in social well-being and, conceivably, the destruction of nature as we know it.

Nevertheless, surely some exploitation of nature is still possible, and perhaps there is no inherent contradiction between social progress and the preservation of nature (see Appendix G for a fuller presentation of this argument). Because the natural environment offers many elements which contribute to the prospects of survival, and enhance the enjoyment of living, the first premise can be accepted and a strong case still made for maintaining natural and near-natural areas: if one takes the longer and wider view that is implied by the last two premises listed above, then the preservation of other species and of natural systems can be regarded as vitally important to improving social well-being (Stauth, 1980).

Goal, Objectives and Criteria

These premises are based on *a priori* judgments that have been instrumental in shaping economic thinking, although not all economists would agree on the validity - or relevance to economic theory - of the last premise. A particular difficulty is to devise an acceptable form of the social welfare function that would explicitly address the distribution of costs and benefits over generations. Nevertheless, the idea of sustainable development is receiving increasing attention (Allen, 1980; Clark, 1989; International Union for the Conservation of Nature, 1980; World Commission on Environment and Development, 1987), and several theorists have made suggestions as to how this problem might be resolved (Boulding, 1971; Daly, 1987; Goodin, 1982; Green, 1977; Herfindahl and Kneese, 1974; Kneese and Schulze, 1985; Layard, 1972; Layard and Walters, 1976; Mishan, 1981; Mueller, 1974; Page, 1977; Pearce, 1983, 1988; Price, 1973; Sharp, 1981). It would appear that the chief difficulty in gaining acceptance for a modification of the social welfare function is the lack of a practical procedure for applying a new criterion pertaining to the concept of sustainability, and the distribution of costs and benefits over generations which are widely separated in time.

In any case, if the six premises are accepted, then the following goal statement can be derived from them.

Goal Statement

The goal of resource allocation is to achieve the highest possible level of social well-being over a time period spanning multiple generations.

While there are ambiguities in this statement - such as what precisely is meant by "social well-being", or the time horizon implied by "multiple generations" - it is believed that precise definitions are not necessary to achieving the general understanding that is needed to establish the goal as a useful guiding principle for decision making, and to derive the evaluation criteria that are both necessary and sufficient to make resource allocation decisions. The central concept is that resource allocation should be directed at improving, to the greatest extent possible, the well-being of all individuals, including those of future generations, and that this should be done by pursuing "paths of social, economic and political progress that meet the needs of the present without compromising the ability of future generations to meet their own needs" (Clark, 1989:20). It is, however, recognized that because it is not possible to maximize two variables simultaneously (Hardin, 1968), difficult choices must be made as to how much should be done to improve the well-being of any one group. In fact, this consideration is what gives rise to the formulation of different evaluation criteria. In any case, the interpretation given in this dissertation to the key terms of the goal statement during the development and application of the formal method of evaluation can be stated as follows.

- Social well-being is defined in terms of the "hierarchy of needs" concept (Maslow, 1970): a society is better off as more of its members satisfy their true, biologically-determined basic needs, and social well-being would be maximized when all of its members have attained self-actualization (*i.e.*, realized their full human potential).

- Multiple generations is understood to encompass all posterity and so extend the time horizon of concern into the indefinite future on the assumption that (1) social progress can and should be perpetuated, and (2) the welfare of remote generations is inherently as important as that of present generations (see the last premise above).

Objectives

An examination of the premises used to derive the goal statement, and the ambiguities and inherent contradictions found within the goal statement itself, leads to the formulation of three sub-goals or objectives to guide resource allocation decisions.

- An action should be efficient (*i.e.*, benefits should exceed costs).

- An action should be equitable (*i.e.*, benefits and costs should be distributed fairly over the different groups comprising present-day society).

- An action should be sustainable (*i.e.*, benefits should continue to exceed costs over intergenerational time periods).

In other words, resource management is directed at making "*efficiency improvements*", "*equity improvements*" and "*sustainability improvements*" in the allocation of scarce resources. Unfortunately, these objectives normally cannot be maximized - and often cannot even be advanced - simultaneously. That is, any given action will have different implications for each of the objectives, and different actions will tend to further different objectives (so that one objective may be furthered at the expense of another). This means that in the evaluation of two or more resource allocation proposals, judgments have to be made as to which action will have the best overall outcome in terms of all three objectives taken together. When considered in this light, the objectives become evaluation criteria, and the evaluation problem is to first judge the performance of each proposal in terms of each criterion, and then to find some means of trading-off the effects in terms of each criterion in order to judge which proposal best meets all three evaluation criteria taken together.

Evaluation Criteria

When the objectives of resource allocation have been re-formulated as evaluation criteria, they may be defined as follows.

- The "efficiency criterion" - an action is efficient if at least one member of today's society is made better off without anyone else being made worse off. (An action may also be regarded as efficient if gainers could potentially compensate losers and still be better off.)

- The "equity criterion" - an action is equitable if it serves to bring about a situation in which the distribution of costs and benefits to present members of society is considered to be improved. (And if gainers actually compensate losers so that the distribution of costs and benefits remains the same or is improved, then that action is both efficient and equitable.)

- The "sustainability (or intergenerational) criterion" - an action has acceptable intergenerational effects if the prospects for improvements in future social well-being are not diminished. (If benefits are expected to exceed costs for future generations, then social progress will be sustainable.)

While intergenerational trade-offs could theoretically be viewed as a problem in efficiency (*i.e.*, whether benefits exceed costs over an indefinite intergenerational time horizon), it is more practicable to view them as an equity problem (*i.e.*, whether costs and benefits are distributed fairly over generations). This is partly because the efficiency criterion is normally conceived by decision makers only in terms of the well-being of their immediate constituency: present members of society. But in addition, an efficiency analysis that tried to incorporate valuations by future generations would be lacking in both rigour and credibility due to the difficulty in forecasting and evaluating such effects. It is therefore preferable to treat intergenerational effects as a temporal distributional problem. Since the term "equity criterion" is commonly understood to refer to the distribution of costs and benefits between groups comprised of present-day members of society, this term has been adopted with that meaning, while the terms "intergenerational criterion" and "sustainability criterion" have been used to refer to distributional effects between present-day groups on the one hand and future generations on the other.

Of the three criteria that have been identified as being both necessary and sufficient to determine whether an action will further social well-being - efficiency, equity, and sustainability - only the first (efficiency) is independent of ethical judgments as to an individual's responsibility to society. All individuals on the selfish-altruistic continuum presumably would desire actions to be efficient, and the greater the net benefits (other things being equal) the better. While there is no such agreement on the other two criteria, the general principles underlying the notions of equity and sustainability are in themselves also rational and unobjectionable; all people should be able to agree that it would be desirable for an action to be equitable and sustainable as well as efficient so long as they and their group would not be seriously threatened or inconvenienced. Therefore, these two criteria are also universally acceptable to apply to resource allocation decisions, since the only real disagreement is how much weight should be given to each of the criteria when applied to a specific action.

In applying the three evaluation criteria to alternative resource allocation proposals, it is necessary to identify and estimate in some way the costs and benefits associated with the proposals. This would include all costs and benefits of concern to anyone, including both adverse and beneficial environmental or social impacts, whether they can be expressed in monetary terms or not.

Ideally, a thorough analysis of this kind would be done for each present-day social group that would be differently affected, then for present-day society as a whole, and finally for future generations. These analyses would then provide a way of judging how well alternative proposals satisfy each of the three evaluation criteria, although it would still be necessary to apply some other approach to trade-off the criteria. In practice, resource limitations and other considerations (including theoretical difficulties) will often restrict the application of a rigorous analysis of this type to present-day society as a whole; this provides a measure of the relative efficiency of proposals, and other approaches can then be taken to apply the equity and sustainability criteria.

Having specified the goal and evaluation criteria to guide resource allocation activity, it is possible to formulate a resource management strategy and environmental evaluation methodology. The next section presents a proposed strategy to establish the context within which an evaluation methodology can be applied.

DEVISING A RESOURCE MANAGEMENT STRATEGY

Simon (1978) has pointed out that when problems become interrelated, as energy and pollution problems have become, there is the constant danger that attention directed to a single facet of the web will spawn solutions that disregard vital consequences for the other facets. The task of improving resource allocation decision making, therefore, needs to be addressed at two levels. At one level there is the problem of applying evaluation criteria to specific resource allocation proposals. But at a broader level there is the problem of determining appropriate policies, legislation and administrative procedures that can serve to constrain and give direction to the entire resource allocation process, including the application of particular evaluation methods. These more general considerations - which taken together may be regarded as a strategy for managing the national resource base - need to be addressed first since they provide the context within which a research methodology for environmental evaluation will be employed.

Because the focus of this dissertation is on developing an environmental evaluation methodology (to address the more specific level of resource allocation decision making referred to above), the following discussion is necessarily brief, and intended only to indicate some of the major considerations and possibilities in devising a management strategy. Nevertheless, certain aspects of the recommended management strategy alluded to here are discussed more fully in the appendices.

Proclaiming a National Conservation Policy

A serious difficulty with resource allocation decisions concerns the fact that almost every resource allocation proposal is considered within a narrowly circumscribed boundary and timeframe of analysis. A proposal that is judged superior to others from a local perspective might not seem as appealing from a national point of view, or from the perspective of future generations; in addition, some resource allocation decisions have major irreversible effects, and therefore if the decision proves to be suboptimal nothing can later be done to improve the situation. For this reason, resource economists such as S.V. Ciriacy-Wantrup have advocated establishing a "safe minimum standard of conservation" (Herfindahl and Kneese, 1974:389). This is a major argument that has been used, in one form or another, by many conservation-oriented economists who would constrain resource allocation choices (Daly, 1987; Herfindahl and Kneese, 1974; Page, 1977). The thrust of the argument is that since almost all resource allocation proposals are judged in a limited spatial and temporal context, in which the more direct and immediate benefits of development proposals have an advantage over the broader and longer-term benefits of conservation proposals, a sub-optimal level of conservation benefits is likely to be provided for society as a whole.

The solution suggested here is that a national conservation policy should be adopted which would specify the type and amount of environmental services to be maintained in various regions of a country. This policy would then provide the framework within which an evaluation methodology, such as that presented in this dissertation, could be applied to competing resource allocation proposals.[1]

Promulgating Legislation on Environmental Management

On 9 June, 1989 the Environment Conservation Act, 1989 (No. 73 of 1989) was signed by the State President of the Republic of South Africa. Among other things, this Act provided for the Minster of Environment Affairs to determine the general policy with respect to environmental matters, to identify activities which may have substantial detrimental effect on the environment, and to declare limited development areas for the protection of certain environmental resources. Furthermore, there is provision for the Minister to make regulations regarding environmental impact reports for those activities designated as being potentially detrimental to the environment, and for restricting developments in limited development areas.

While the Act itself does not contain a statement of policy, or even a desideratum that would clarify the intent of Parliament, the Draft Bill on Environment Conservation, published in the Government Gazette on 30 October 1987, clearly defined the principles and objectives on which a policy of environmental conservation and management in South Africa should be based. The bill first sets out the following statement of principles:

(a) *Every inhabitant of the Republic of South Africa is entitled to live, work and relax in a safe, productive, healthy and aesthetically and culturally acceptable environment.*

(b) *Every human generation has a moral responsibility to act as trustee of its natural environment and cultural heritage in the interests of succeeding generations.*

(c) *Every person or institution has an obligation to consider carefully all actions which may have an influence on the environment and to take all practicable means to ensure the protection, maintenance and improvement of both the natural and the man-made environments.*

(d) *The preservation of natural systems and processes is essential for the meaningful survival of all life on earth.*

(e) *Living natural resources are renewable and can be utilised indefinitely with discretion, while non-living natural resources are finite and their utilisation can only be extended by judicious use and maximal re-use.*

(f) *Coordinated and purposeful research is essential to gain and apply knowledge of all the facets of the environment and the interaction between man and*

1 Because of the fundamental importance of this argument, a fuller exposition is provided in Appendix G.

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environment, in order to reconcile provision for the reasonable needs of man with effective protection of the environment.

(g) *Comprehensive and sustained tuition and interpretation and dissemination of information is essential for the establishment of an informed population for the promotion of rational utilisation of the total environment.*

The Bill then goes on to set out the general environmental concerns or objectives which a national policy on environmental conservation and management must address (these concerns are also identified in the Act):

(a) *the protection of ecological processes, natural systems and exceptional natural beauty as well as the preservation of biotic diversity in the natural environment;*

(b) *the promotion of sustainable utilisation of species and ecosystems and the effective application and re-use of other natural resources;*

(c) *protection of the environment against unnecessary disturbance, deterioration, defacement, poisoning or destruction as a result of man-made structures, installations, processes or products; and*

(d) *the establishment, maintenance and improvement of living environments which contribute to a generally acceptable quality of life for the inhabitants of the Republic of South Africa.*

As indicated in the above, the government of South Africa has recognized a solemn obligation to provide a high-quality environment for all its people, including generations to come, and to provide for the continued existence of other life forms found within its borders, including the systems that support these life forms. Specifically, the South African government has a responsibility to:

- Develop national resources to ensure harmonious interaction between all aspects of the country's natural and man-made environments.
- Act as steward and custodian of environmental resources for all of its people, both now and in the future.
- Reconcile the goals of development and conservation by making resource use more efficient, more equitable and more sustainable.
- Take measures to redress past mistakes and inequities, and restore environmental quality as far as possible.

Adopting Administrative Procedures for Processing Resource Allocation Proposals

In South Africa, the Council for the Environment has recently recommended that all central, provincial and local branches of government begin applying the principles and concepts of "*Integrated Environmental Management*" (see The Concept of Integrated Environmental Management in this chapter and Appendix H). Integrated Environmental Management provides a set of operational guidelines for processing development and conservation applications. The object is to ensure that all resource allocation proposals which are subject to the approval of some authority, and which could have significant impacts on the quality of the human environment, are subjected to a systematic and thorough review and evaluation process. This would include procedures such as "*screening*" and "*scoping*", and procedures for preparing a public record of decision and an environmental control plan for those proposals which have particularly significant environmental implications. If these procedures are widely adopted and applied, Integrated Environmental Management will serve as an important component of the recommended resource management strategy.

The South African system of government is currently undergoing profound changes, and more responsibilities are now being delegated to provincial, regional and local levels of government. In some areas there is a lack of staff and expertise at these lower levels of government to properly investigate the environmental implications of development proposals and ensure that environmental considerations are taken into account at each stage of the development process. For this reason, the Council for the Environment has suggested that whatever administrative structures eventually evolve, and regardless of how decision making responsibilities are delegated, there should be close interaction between the various levels of government to develop a coordinated national strategy for integrating environmental concerns into the planning, decision making and management process (S.A. Council for the Environment, 1989:30-31).

The Council has also suggested that structural and staff inadequacies in the present administrative framework could initially be ameliorated by establishing groups of staff with environmental training at the second (provincial) tier of government. This is important because most development and conservation proposals will be processed at the second and third tier. Authorities at all levels could eventually develop environmental expertise for conducting or overseeing environmental investigations, and for preparing or evaluating environmental documentation. Many authorities could then develop, test, and eventually promulgate their own regulations for implementing the principles and concepts of Integrated Environmental Management.

FORMULATING AN ENVIRONMENTAL EVALUATION METHODOLOGY WHICH FEATURES A FORMAL METHOD OF EVALUATION

Once a resource management strategy has been articulated, the next level of resource allocation decision making can be addressed. This is the problem of how to evaluate competing resource allocation proposals. This section is concerned with developing an environmental evaluation methodology for applying criteria to specific resource allocation proposals.

The Concept of Integrated Environmental Management

In the United States and other countries, Environmental Impact Assessment has evolved over the years and now goes far beyond the original practice of only assessing the environmental implications of proposals when they are at an advanced stage of formulation. In recent years, greater attention has been given to other phases or aspects of environmental resource management, including environmental planning, decision making and implementation of environmental control plans (Burton *et al.*, 1983; Hollick, 1981b, 1986; Rossini and Porter, 1983). In addition, whereas Environmental Impact Assessment was initially directed almost exclusively at specific projects, it is now recognized that the process should be more widely applied to programmes and policies as well (Clark, 1984; Lee, 1982; Robinson, 1989). In South Africa, the term Integrated Environmental Management is used to describe this more general set of assessment and evaluation activities pertaining to environmental resource management.

As discussed in the previous section, Integrated Environmental Management may be regarded as a general administrative procedure for processing development applications. But regarded in a different way, the principles and concepts of Integrated Environmental Management may be thought of as constituting a methodological framework for environmental evaluation; this is because Integrated Environmental Management provides a means for relating environmental theory to empirical research, and provides operational procedures for guiding scientific inquiry directed at gathering and processing value information.

The central concern of Integrated Environmental Management is to ensure that environmental considerations are fully integrated into all stages of the development process:

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proposal generation, assessment, decision and implementation (see Figure 4.1). Special emphasis is to be placed on environmental planning, and there is a feedback loop from the assessment stage to the proposal generation stage so that proposals can be modified as a result of information acquired during assessment.[2]

Informal evaluation is inherent in all stages of Integrated Environmental Management, and it is not always necessary to undertake a formal evaluation at any stage. If there is relatively little controversy surrounding a proposal, then the proposal can simply be subjected to normal analytical procedures by environmental planners, analysts and decision makers. In fact, for many major resource allocation proposals, a formal or highly-structured evaluation technique may not be considered necessary or practical, and the evaluation process can be accomplished through the political process provided that there is a well-structured administrative procedure - based on the principles of Integrated Environmental Management - that is acceptable to all potentially concerned parties.

This approach does not necessarily utilise any formal Environmental Impact Assessment methods or techniques, or even any systematic or rigorous evaluation procedures at any stage, but rather relies on informed interaction between concerned parties throughout the planning and assessment process to accomplish a relatively unstructured and informal evaluation of the relative merits of various suggestions.[3] The idea is that decision making is complex and sequential in nature, that forecasting and evaluation should go hand in hand, that these are continuous and iterative tasks, and that common-sense evaluations can inform and correct the planning and design process (Conover *et al.*, 1985; Haug *et al.*, 1984a, 1984b; Hollick, 1981b; Norton and Walker, 1982).

Finally, by the end of the planning and assessment process the responsible authorities should have a good feel for the social significance of various outcomes, and no special evaluation technique or formal evaluation procedure may be needed. This ubiquitous and relatively successful approach to evaluation relies heavily on the free exchange of information between all concerned parties: proposers, authorities, and affected publics. Of particular importance are (1) the cooperative arrangements between authorities who share jurisdiction or have relevant expertise, and (2) the arrangements for involving or consulting the various publics who could be directly affected or who may have special knowledge or information.

A very high proportion of environmental conflicts can be resolved satisfactorily using this approach. Nevertheless, when there is likely to be great disagreement or controversy over which of two or more proposals would be in the greater public interest, it is highly desirable to conduct more formal evaluations during the assessment stage. In fact, it is suggested that the following decision rule should be adopted: if a resource allocation proposal is not controversial, or conflict can be resolved through negotiation, mitigation and compromise, then only informal evaluations need be conducted; however, if a proposal is controversial and there is no reasonable prospect of resolving the conflict, then a formal evaluation should be conducted.[4]

Formal evaluations (as defined in this dissertation) are directed at optimizing, and this type of evaluation involves the systematic gathering and "weighing up" (using quantitative methods) of value information so that the valuation process is made explicit. Cost-benefit Analysis (see Chapter 3) is one widely-accepted method for conducting formal evaluations. While several sophisticated approaches have been developed for obtaining more complete and accurate information as to the value of anticipated outcomes (see Shadow-pricing Techniques in Chapter 3), the use of these techniques will increase the already high cost of conducting a Cost-benefit Analysis. It may therefore not be thought practical to adopt these approaches in developing

2 Appendix H presents a discussion of the relationship between planning, assessment and decision making, as well as more details of the principles and concepts of Integrated Environmental Management.

3 The emphasis in Integrated Environmental Management, as currently practiced in South Africa, is on the use of informal evaluation procedures, and the document, Integrated Environmental Management in South Africa, does not provide specific guidance for conducting formal evaluations.

4 For a discussion of the rationale underpinning this decision rule, see Appendix I.

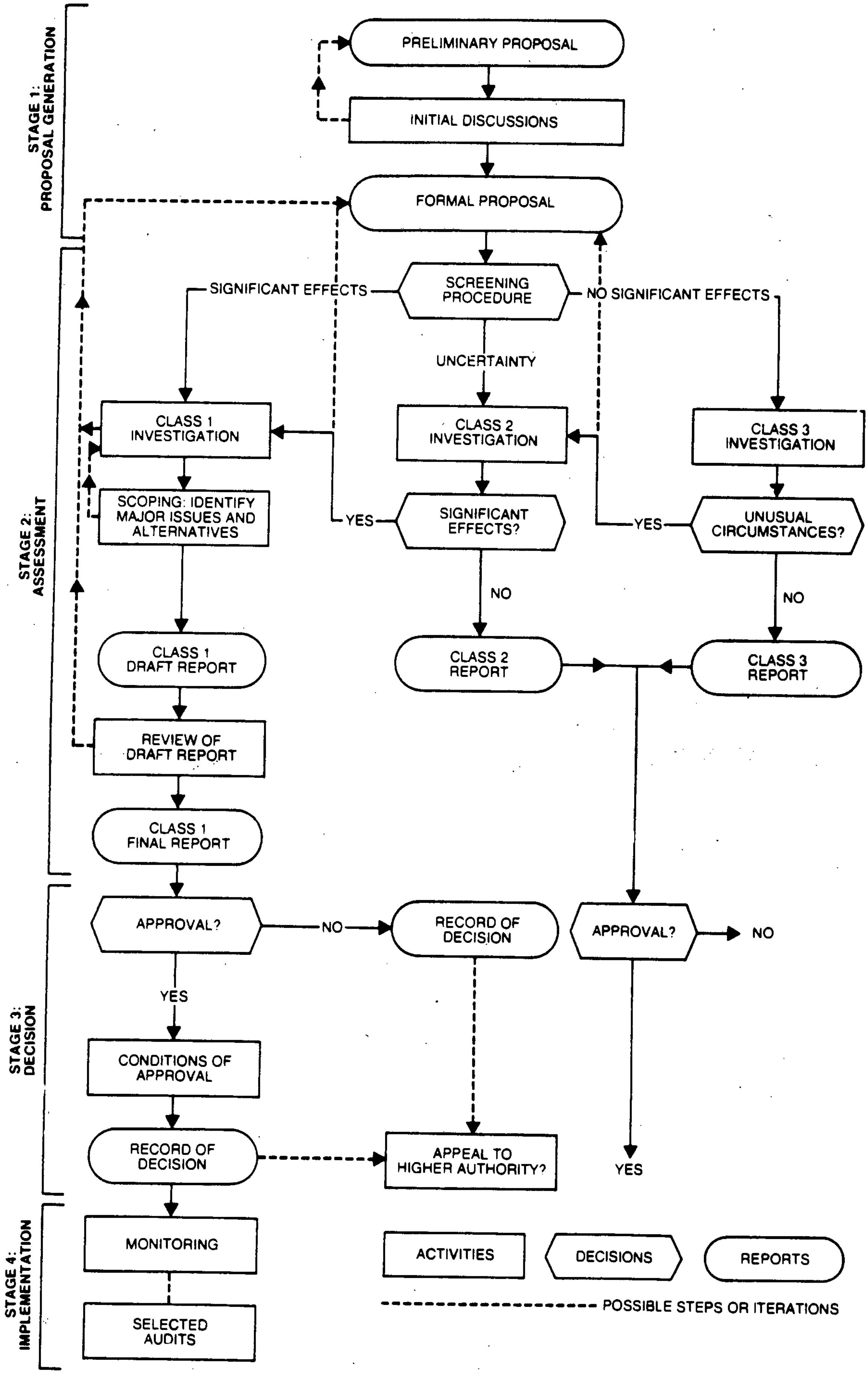

FIGURE 4.1 **Schematic Diagram to Illustrate the General Integrated Environmental Management Procedure (from S.A. Council for the Environment, 1989)**

countries which have limited budgets and expertise for environmental evaluation. Nevertheless, even if a full Cost-benefit Analysis cannot be accomplished, low-cost variations of these techniques may still be used to estimate the approximate value or relative significance of important unpriced costs and benefits, and so improve the evaluation process in difficult or controversial cases.

In any case, it is necessary to develop, as a central feature of the environmental evaluation methodology, a formal method of evaluation which can be applied to especially controversial resource allocation proposals. The next section discusses the development of a set of procedures for conducting formal evaluations.

Developing Formal Evaluation Procedures

The general principles and concepts of Integrated Environmental Management provide a sound foundation for an environmental evaluation methodology. In addition, shadow-pricing techniques and other approaches to indirect pricing can be used to reduce value uncertainties or simplify evaluation within a conventional cost-benefit framework. Yet there are occasions, such as when proposals are especially controversial, when a formal evaluation is considered necessary, but there are many impacts which are impossible to value in monetary terms. It may also be too difficult to conceptualize the trade-offs involved against a single contingency price or threshold value. Then other procedures are needed to adequately direct scientific inquiry and satisfy all the requirements for relating theory to empirical research.

There is thus a need to develop, for proposals that are especially controversial, a set of procedures for unambiguously identifying which of two or more mutually-exclusive alternatives would best satisfy specified evaluation criteria. This set of procedures should be applicable to any resource allocation proposal, and should make provision for the application of shadow-pricing techniques, but not rely on them (because they are often thought too expensive or unreliable).

The development of formal evaluation procedures involves several challenges. Foremost among these challenges is to ensure that the evaluation process is clear and open, easy to understand, practical to implement, and acceptable to most people. Among other things, this means that the approach to evaluation must be comprehensive, systematic and explicit. Of particular concern is the problem of developing an acceptable procedure for obtaining, in a reliable and cost-effective way, measurements of the relative significance of a long list of completely nonmonetizable impacts.

The principal concern in developing a set of formal procedures for evaluating controversial resource allocation proposals was to discover a reasonable way to evaluate the relative efficiency of competing proposals. But it was also necessary to provide a means for systematically applying and trading-off other evaluation criteria, and to ensure that these judgments are formally expressed and recorded.

Issues Arising from the Adoption of a Cost-benefit Framework

The conceptual framework that was adopted for evaluating controversial resource allocation proposals is based on Cost-benefit Analysis. While Cost-benefit Analysis has been widely used throughout the world, and is generally regarded as being both theoretically sound and practical to implement, there are several problems that have not been satisfactorily resolved. As Kneese (1984:5) points out, the new applications of Cost-benefit Analysis bristle with ethical, value and quantification issues. Among the issues that concern theorists and practitioners of Cost-benefit Analysis are the following.

- How should one treat the distribution of costs and benefits among individuals or regions; is it sufficient to consider only the sums over all affected parties?

- How does one treat ethical issues, such as when one group exposes another to hazard?

- How can the rights and preferences of future generations be represented in the decision making process?

- How does one treat risk and uncertainty, or preferences when individuals obviously have insufficient information on the probability and meaning of alternative outcomes?

- How does one determine the proper weighting of costs and benefits occurring at different times?

- How can one estimate the value of costs and benefits which cannot be quantified using purely objective measuring techniques, or are not normally valued in monetary units?

These issues were all considered in the development of the set of procedures for conducting a formal evaluation which is presented in this chapter. In general, the issues concern the implications of resource allocation activity for

- different groups comprising society (the equity criterion)

- future generations (the sustainability criterion)

- society as a whole (the efficiency criterion).

The general approach that was adopted toward each of these issues is briefly summarized (in the same order presented above) as follows.

- The distributional consequences of an action are to be explicitly weighed against other criteria (namely efficiency and sustainability).

- Ethical questions can be treated as costs to particular groups and to society as a whole, and so are to be treated as both an equity issue and an efficiency issue.

- The consequences of an action for future generations are to be explicitly weighed against other criteria (namely efficiency and equity).

- The probability of obtaining benefits or incurring costs can influence the weight that is given to benefits and costs, and preference weightings can be based on what is assumed would be wanted if information possessed by the evaluator(s) was in the possession of all individuals.

- Conventional discounting procedures can be employed to adjust the value that present groups attach to costs and benefits that will be received by them in the future.

- A scaling procedure can be used to determine the relative significance of costs and benefits which are unpriced and which cannot be meaningfully quantified in some more objective manner.

The two major questions that remained to be answered were:

- Who should do the evaluating?

- What specific scaling and trade-off procedures should be employed?

Selection of a Group Evaluation Procedure

The approach that was adopted for evaluating controversial resource allocation proposals is based on a group evaluation procedure. The individuals who comprise the group are to be respected members of society who are regarded as being essentially unbiased toward the proposals being evaluated. The rationale is that if evaluations of resource allocation proposals which are highly controversial are undertaken by persons who are not respected, or who are perceived to have a vested interest in the outcome, their judgments are not likely to be accepted by some or all of the concerned parties.

There are other reasons for selecting a group evaluation procedure rather than relying on the value judgments of the decision maker or some "expert". The system of values held by the expert or decision maker may not accord with the values held by the affected parties, and many people may simply not trust the decision maker - or even a person who is considered to be an expert in some particular discipline, no matter how relevant his expertise may be to the decision - to conduct a thorough evaluation.

Furthermore, because controversial resource allocation proposals are generally characterized by great complexity and heated emotions, decision makers might well welcome an unbiased evaluation conducted by a group of persons who collectively represent a number of disciplines and constitute a great pool of experience and knowledge. In addition, there is evidence that it is possible to obtain better and more acceptable judgments from groups than from any given individual (Dalkey *et al.*, 1972:6; Hill, 1982; Miller, 1985; Rohrbaugh, 1979).[5]

Granting the desirability of involving a group of respected persons in the evaluation of particularly contentious or difficult resource allocation proposals, there is still a need to devise a set of procedures for facilitating intergroup communication so that special information, experience and insight can be shared. Two different approaches to group evaluation were considered especially promising and were therefore selected for testing: the Delphi method and the Nominal group technique (see Delphi and Nominal Group Technique in Chapter 3).[6]

There is evidence to indicate that group judgments made using Delphi procedures are generally more reliable than individual judgments or group judgments obtained in other ways. Dalkey *et al.* (1972:4-6,20), in experiments involving estimates of data which would not be common knowledge, found that in general the error of the average of a group of estimates is much smaller than the average error. Perhaps even more interesting, it was observed that group judgments following face-to-face discussion results in less accurate group response than a simple median of individual estimates without discussion. The best results of all were obtained using a Delphi technique.

Conventional Delphi techniques rely on questionnaires returned by post, and this is done primarily to maintain complete anonymity (Linstone and Turoff, 1975:5; Pill, 1971:57; Richey *et al.*, 1985a:137). Although Delphi is normally associated with forecasting (Pill, 1971:59) it has also been used to obtain group evaluations of data sets (Dalkey *et al.*,1972:55). The application of Delphi procedures presented in this dissertation differs from conventional Delphi techniques principally in providing the capability to complete an evaluation in a short time by allowing members of the panel to be physically present in the same room; this helps maintain panel interest and makes it possible to complete a Delphi evaluation in 3 or 4 hours.

Although the identity of fellow panelists is revealed in a meeting situation, anonymity of response and other controls on group interaction are achieved through procedural mechanisms. This is important since overt group interaction can have an inhibiting and obfuscating effect on individual thinking, leading to process losses which distort group judgments and prevent the group from realizing the full benefit from cognitive feedback and stimulation (Hill, 1982:535; Rohrbaugh, 1979:75). The adaptation of the Delphi method presented in this dissertation bears some resemblance to the Nominal Group Technique (see Delphi and Nominal Group Technique in Chapter 3), in which group interaction is strictly controlled by a group facilitator, but differs from that technique in that participants are not allowed to communicate opinions or judgments except by an anonymous process. (Panelists are, however, allowed to verbally communicate questions or query statements of fact in the interests of saving time.) One of the reasons for this adaptation (in addition to speeding the group judgment process) is that there appears to be a

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5 Appendix J presents the argument for adopting a group evaluation procedure in more detail.

6 In the first case study, only the Delphi method was employed; in the second case study, the Nominal group technique was used to identify impacts for evaluation, and the Delphi method was used to actually accomplish the evaluation.

valuable stimulative effect when persons work in the presence of their peers or people whom they respect.

In addition to being more reliable than other group methods, the essentially democratic nature of the Delphi method is satisfying both to the participants and to the users of the information. Also satisfying is the fact that the method is based on rational analytical principles, and the approach that is taken to forecasting and evaluation is comprehensive, systematic, explicit and unemotional. The environmental evaluation process is put on a more solid foundation when it can be seen that arguments do not depend on emotional rhetoric, and that conclusions are not based on arbitrary assumptions, hidden or ill-defined goals, or questionable logic.

The Problem of Measuring the Significance of Impacts

The issue that received greatest attention in the development of formal evaluation procedures was the quantification issue: the problem of estimating the value of costs and benefits which cannot be expressed in monetary units. The reasoning was that if an acceptable technique for scaling the value of unpriced impacts could be found, this would greatly facilitate the evaluation process. First, if all costs and benefits could be measured on an interval scale, then it would be much easier to judge whether a proposal with many unpriced impacts is efficient or not. In addition, a full determination of the relative significance of unpriced costs and benefits would help in evaluating the distributional consequences of proposals, and in making more meaningful comparisons of the net effect for present and future generations.

The classic "conservation vs. development" conflict generally revolves around the question "Do the adverse environmental impacts (or nonmonetary costs) of a development outweigh its net monetary value?" While many development actions do have significant nonmonetizable benefits, most of the benefits can usually be monetized, whereas many of the opportunity costs of the development (such as loss of ecological and amenity benefits associated with a competing conservation proposal) are not so easily monetized. In fact, many such impacts cannot be satisfactorily measured using any objective method (*e.g.*, reduction in breeding success for some rare or endangered species, or reduction in scenic resources); others are measured using different scales and their values are expressed in different units (*e.g.*, millilitres per litre, cubic meters per second, or calories per gram).

While shadow-pricing techniques may reduce the area of uncertainty, very often there are still several adverse but completely nonmonetizable effects to weigh against the net monetary value of a project. Then the decision maker is presented with the very difficult problem of how to weigh one known value against that of several incommensurable values, and judge whether the value of the former outweighs the combined value of the latter.

In the course of this research, it was decided to extend the capabilities of Cost-benefit Analysis and the logic of threshold valuation (see Chapter 3) to deal with the situation in which a large number of nonmonetizable effects are listed for some controversial resource allocation proposal. According to Dohan (1977:164), if there is a long list of effects which are completely nonmonetizable, then all one can do in a Cost-benefit Analysis is list them boldly against the excess monetary value of the development. In other words, the analyst can only provide the decision maker (and interested parties) with a qualitative description of these nonmonetizable impacts so that these concerns can then be collectively weighed (through some individual and ill-defined subjective process) against the monetary value of the proposal.

But this is not very satisfactory because the task involves algorithms that are beyond the ability of most people to apply: the individual is left to weigh the combined value of a large number of complex outcomes expressed in incommensurable units with a given (and generally large) sum of money. The result is likely to be a rather arbitrary evaluation: the decision maker will tend to focus on one or two impacts that seem to him to be of some consequence, or of concern to some special interest group that might represent an important part of his constituency, and the evaluation will then not be systematic, comprehensive, or explicit.

Obviously, if there were only one nonmonetary impact to be compared to the net monetary value of the development project, the analysis would be relatively simple. In this case, the net monetary value would represent a contingency price for a single impact, so there would be a straightforward one-for-one comparison. The question would then simply be whether the calculated sum of money (to society) is worth (being contingent upon) accepting the one impact. Unfortunately, such simple one-for-one comparison are not the rule, and it is extremely difficult to juggle several unpriced impacts in one's mind at the same time, taking proper cognizance of each, and comparing their total value to the value of a single sum of money (and the larger the sum the more difficult it is to conceptualize its value).

Dohan (1977) illustrates the current approach that practitioners are taking to applying Cost-benefit Analysis with an example concerning a proposed development that would eliminate or reduce valued public service functions flowing from a salt marsh (see Cost-benefit Analysis in Chapter 3). In Dohan's example, the present discounted value of the development proved to be negative when shadow prices were obtained for some of the development's unpriced costs. But very often shadow prices cannot be obtained, or the present discounted value remains positive and must be weighed against a long list of nonmonetizable impacts.

To illustrate, assume that in Dohan's example the present discounted value of the development (which might be, for example, a marina project) is calculated to be R9,550,000, and a shadow-price analysis of the externalities that would result from the development indicates that society would incur external economies of R50,000 (from the reduction of noxious insects) and external diseconomies of R600,000 (from reductions to fishery production, loss of recreational opportunities, and impaired functioning of natural flood dampening mechanisms). The net monetary value of the project is therefore estimated to be R9m..

However, assume that ecological studies and social surveys indicate that other significant costs would result from the project, such as

- the loss of critical habitat for water birds
- increased threats to an endangered species
- reduced groundwater storage capacity
- diminished pollution assimilation capacity
- lost options and reductions in unknown services
- loss of open space
- diminished aesthetic, scientific, and educational benefits associated with the marsh.

If these costs are considered completely nonmonetizable (or too expensive to estimate with shadow-pricing techniques), then the decision maker must find some way to determine whether the loss of these nonmonetary benefits outweighs the net monetary gain from the project.

In effect, the calculated monetary value of the project - R9m - represents a threshold value or contingency price for the several unpriced wetland benefits, and the problem is to decide whether these benefits are worth more or less than this amount. If they are worth less, then the development proposal constitutes a more efficient allocation of resources than does the conservation proposal; if they are worth more, then conservation would be more efficient than the development. But it is extremely difficult to conceptualise the value of all these unpriced costs and weigh them against a single monetary figure (the value of which is also difficult to conceptualise).

A Proposal for Resolving the Measurement Problem

To facilitate the evaluation process in such situations, a variation of the threshold valuation procedure has been developed during the course of this research. This procedure - called "*fractional contingency price valuation*" - involves scaling or weighting the values of all impacts, so that the relative value of these impacts can be determined. Then it is possible to calculate a "fractional" contingency price for any one of those impacts, based on what would be its "share" of the total contingency price (*i.e.*, the net monetary value of the project which has the excess monetary value). This fractional contingency price can then be evaluated for reasonableness, and the decision making problem becomes identical to the one which involves only one impact against one sum of money:

> Does the value of the nonmonetary impact (which has been selected for evaluation) outweigh the value of the monetary gain (which has been calculated for this impact)?

The fractional contingency price valuation procedure thus simplifies a complex evaluation problem without unduly distorting it, and presents the decision maker with a clear, straightforward choice between a given sum of money and a single adverse impact. In effect, the decision maker then has only to decide whether the sum of money (which is relatively small and more comprehensible, being a fraction of the original contingency price) would be adequate compensation to society for bearing the impact in question. If the answer is yes, then the project is efficient; if the answer is no, then the project is inefficient.

There are two variations of the fractional contingency price valuation procedure to suit different situations but both are concerned with reducing the complex problem of comparing the value of a large monetary gain against a large number of nonmonetary impacts to a more manageable problem of comparing a smaller sum of money against a single nonmonetary impact, and to do this in a way that is logical, inexpensive, and acceptable to all parties.

The simplest case involves a situation in which only one of two alternatives has nonmonetary impacts for which shadow prices cannot readily be determined (see Box 4.1). Expanding on the previous example, assume that the most promising alternative to the marina development which would eradicate the salt marsh is to proclaim the wetland as a nature reserve and recreation area. If the calculated present discounted value of the marina development is R9m, and the present discounted value of conservation is -R1m (the figure being negative because outlays are anticipated to exceed revenues), then the excess monetary value of development over the nature reserve is R10m. Assume also that there are 10 adverse impacts that would result from the marina development, and that it is possible to judge, by applying an acceptable "*fractionation technique*" (which will be discussed later), the relative significance of all the adverse impacts.

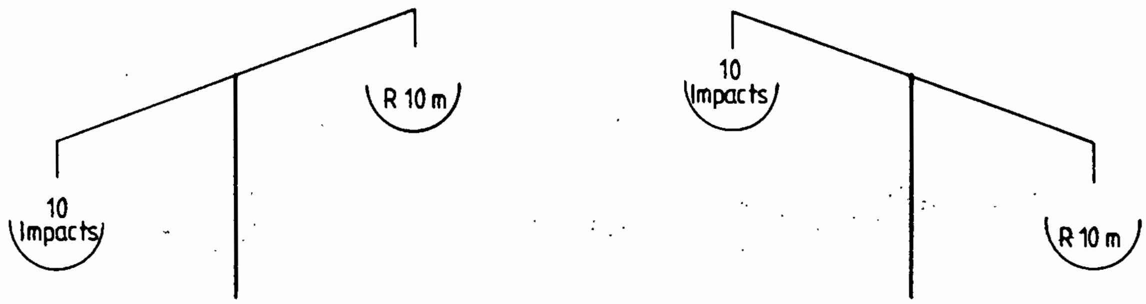
Now if one impact (such as lost recreational opportunities) is judged to constitute 20% of the value of all the impacts, then a contingency price of R2m can be calculated for lost recreational opportunities, and the question can be asked: "Is R2m adequate compensation for bearing the loss of recreational opportunities associated with this wetland?" If the answer is yes, then the development option is to be preferred on efficiency grounds; if the answer is no, then conservation is to be preferred. The decision maker can now use one shadow price (instead of several) to make the efficiency determination; or, if no shadow prices have been obtained, he can simply calculate a contingency price for any one impact and make the efficiency determination based on the available evidence and his best judgment. In any case, if it can be assumed that the proportional weighting of this impact has been correctly estimated, the decision making problem has been simplified without distorting the nature of the total trade-off.

A more complex case exists when both proposals have significant nonmonetary costs. Very often, however, one of the proposals will be directed at modifying the environment to create monetizable benefits, while the other will be directed at conserving the environment to save nonmonetizable benefits. In this case, the proposal which has the excess monetary value will usually have more unpriced costs than the alternative proposal, simply because the former is usually concerned with monetary gain and the latter is usually concerned with saving unpriced environmental resources. In addition, the unpriced costs associated with the latter will often be relatively inconsequential, so that they are not likely to alter the conclusion that would be made from the comparison between a single impact and its contingency price. For example, the proclamation of a national park might involve the displacement of a few families and restrictions on the exploitation of certain resources, but these costs may be considered minor in comparison with unpriced environmental costs associated with alternative development proposals, especially if there has been provision for a reasonable level of compensation and mitigation (see Case Study 1 in this chapter). If, however, two or more alternatives have significant nonmonetizable costs, it is possible to apply a more complex form of the fractional contingency price valuation procedure. (This variation of the procedure is explained and applied in Case Study 3, which is presented in Chapter 5: see Task 9, Analyze the Results and Prepare an Environmental Evaluation Report.)

BOX 4.1
Example of Fractional Contingency Price Valuation

__Given that__:
The present discounted value of a marina is R10m, but the marina will cause 10 unpriced adverse impacts and no unpriced beneficial impacts.

__The question is__:
Would the social cost of these 10 impacts be worth more or less than R10m?



It is difficult to weigh the combined value of 10 impacts against one large sum of money. So the decisionmaker may have a respected panel determine the relative significance of each impact. Then it is possible to calculate a contingency price for any one impact.

__For example__:
Assume that the social cost of one impact - Impact X - is judged to be 20% of the total social value of all 10 impacts. Then a contingency price of R2m (R10m x 20%) can be calculated for Impact X.

Now if the monetary value of Impact X is thought to be greater than R2m, the combined value of the remaining 9 impacts must be greater than R8m. Therefore the total social cost of the marina would be greater than R10m. In this case, the costs of the marina wold outweigh the benefits. By the same token, if the value of Impact X is thought to be less than R2m, then the benefits of the marina would outweigh the costs.

This extension of Cost-benefit Analysis and threshold valuation obviously depends on the existence of an acceptable technique for determining the relative value of unlike goods for which prices do not exist because these goods cannot be owned and traded in the market. In order to apply the fractional contingency price valuation procedure, it is necessary to obtain a reliable measure of the significance of impacts on an interval scale. The question is: after the net monetary value of a project has been calculated by Cost-benefit Analysis, and after the nonmonetizable impacts have been analyzed in an Environmental Impact Assessment, how can one determine what fraction of the total contingency price should be assigned to each adverse impact? The fractional contingency price valuation procedure is dependent on the availability and acceptability of a technique for obtaining acceptable measurements of significance on an interval scale when undertaking evaluations of subjective data.

A Technique for Scaling Impacts

The central measurement problem addressed in this dissertation is how to relate all the benefits and costs of a proposal, both monetizable and nonmonetizable in nature, in order to determine whether (and by how much) the benefits of a proposal exceed its costs, so that competing proposals can be ranked according to the efficiency criterion. In order to estimate the true net benefit of a proposal, it is necessary to measure costs and benefits using an interval or ratio scale. There are two general approaches to obtaining interval or ratio measurements (see Methods of Scaling Data in Chapter 3):

- using a variability method (such as the paired-comparison method) in conjunction with a scaling model (such as Thurstone's Case V Scaling Model) to obtain a higher-ordered metric scale; or

- using a quantitative-judgment method (such as the fractionation method) to directly obtain interval or ratio measurements (Green and Tull, 1978).

The first approach involves relatively simple judgments (whether one item is more or less important than another), but requires many paired-comparisons to obtain a higher-ordered metric which adequately conveys the respective utilities of items so that these can be summed and compared. On the other hand, the second approach provides a direct interval or ratio measurement, and therefore does not require a great number of judgments; thus the measurement task can be accomplished much more quickly than with the first approach. In addition, people seem to intuitively grasp the concept of ratio measurement, and appear to often apply ratio concepts to subjective data (Stevens, 1957; 1975).

It was therefore decided to employ a quantitative-judgment method for estimating the relative significance of unpriced impacts. The problem of subjective scale units can be easily resolved by normalizing scores. There are other difficulties with obtaining group measurements of data on a ratio scale (such as the problem of subjective origins - *i.e.*, the lack of a common benchmark or zero point for scaling items), but since ratio-scoring is readily understood, generally accepted, and can be accomplished relatively quickly, it was decided to adopt this general approach for initial trials in the development of formal evaluation procedures.

An important consideration in the development of a technique for scaling impacts is to reduce the cognitive load on the persons who are to do the evaluating. The idea is to progress gradually with the task of measuring the significance of items so that respondents will become more familiar with the data and comfortable with the task by applying relatively simple procedures first. This is particularly important if the list of items to be scaled is very long. In such a case rank-ordering would greatly facilitate ratio-scoring, and a simple rating procedure could be used to facilitate the rank-ordering. Therefore, the technique that was adopted involves three different methods of scaling data: two variability methods (rating and then ranking), and a quantitative-judgment method (fractionation).

- The first step of the technique is to rate the impacts on a 7-point scale to get some feel for the relative importance (or social significance) of the impacts. Seven levels of discrimination provides for a reasonable degree of differentiation (to aid in the ranking procedure to follow) without exceeding what is probably the average individual's ability to discriminate between degrees of importance (Guilford, 1954:290).

- The second step is to use the rating scores to rank-order the impacts. This step should be easy to accomplish since the ratings can be used to assist in the rank-ordering: only those items that have been given the same rating will have to receive special attention.

- The third step is to estimate the ratio of importance between each pair of impacts. Since the impacts have already been rank-ordered, all that is needed is to judge the ratio of importance between pairs of impacts using some acceptable fractionation procedure. Finally, because it is presumably easier to judge ratios which are relatively small (rather than, for example, those which are of an order of magnitude or more), the fractionation procedure adopted involves comparisons between adjacent impacts on the rank-ordered list rather than comparisons between the most (or least) important impact with every other.

Delphi procedures are an integral part of the technique. The technique involves three iterations of rating, followed by one iteration each of ranking and ratio-scoring. Panelists are presented with lists of impacts for each proposal under consideration, and a separate evaluation is conducted for each list. First each panelist is asked to rate the importance of the impacts (for each list in turn) on a scale of "1" to "7": "1" signifying "of no importance" and "7" signifying "of extreme importance". Group ratings are calculated, and the results are fed back to the panel so that panelists can reconsider their ratings in light of the group judgment, and the process is repeated (normally twice more). Each panelist is then asked to undertake a final rating and use this rating to rank the impacts in order of importance to facilitate the ratio-scoring or weighting procedure that follows.

Once each panelist has the impacts on a list ranked in order of importance, the next step is to determine just how much more important one impact is when compared to another. This can be done through a scaling procedure which involves systematically evaluating the importance (or "*weight*") of each impact compared to the impacts he has ranked below it. A fractionation procedure termed "fractional paired comparison" was chosen to determine the relative value of impacts. Following is a brief description of the procedure, illustrated by an example (see Box 4.2).

The highest ranked item is assigned the value "1". The second ranked item is then compared to the highest ranked item, and a number between "0" and "1" is chosen which indicates the value of the second ranked item relative to that of the first (see second entry in column two of Box 4.2 - "Weighting"). Then the third ranked item is compared to the <u>second</u> ranked item in the same way: a number between "0" and "1" is assigned which indicates the proportion of the total value that has been ascribed to the higher ranked item that is associated with the lower ranked item. This process is continued until each pair of items on the list have been scaled in the manner described.

Then the relative value of each item to every other item can be calculated. Since the relative value of the first and second ranked items is known, and the relative value of the second and third ranked items is known, it is possible to calculate the relative value of the first and third ranked items. This is done by multiplying the value assigned to the third ranked item by the product of the values assigned to the first and second ranked items (see column "Adjusted Weightings" in Box 4.2). This result can then, in turn, be multiplied by the value assigned to the fourth ranked item to calculate its value relative to the three items ranked above it. This procedure is repeated until the weightings of all items have been adjusted. The final step is to normalize the adjusted weighting scores so that each can be expressed as a percentage of their total value (see column "Normalized Score" in Box 4.2). This is done by simply dividing the adjusted weighting for each item by the sum of all adjusted weightings. Now the relative value of all items has been determined.

From these individual evaluations, a group judgment as to the relative significance of the impacts can then be derived. The problem of individual scale units is avoided with this procedure because all panelists must use a specified ratio scale ("0" to "1") for each comparison, and the weightings are subsequently adjusted to obtain a normalized score on a percentile scale which is then additive. The problem of subjective origins is, however, still a difficulty with this procedure, since all panelists must assign the number "1" to the top-ranked impact, and the perceived importance of this impact may vary considerably between panelists. Nevertheless, it was decided that when dealing with issues involving value judgments, a group judgment was still preferable to the judgment of any one individual, even if there was some distortion in the aggregation process.[7]

BOX 4.2
Example of Fractional Paired Comparison

Rank Order	Original Weighting	Adjusted Weighting	Normalized Score
E	1,0	1,00	49
B	0,5	0,50	24
C	0,8	0,40	19
F	0,2	0,08	4
D	0,5	0,04	2
A	0,9	0,04	2
Total		2,06	100

Explanation

The top-ranked impact (E) is given a weight of 1,0.

The second-ranked impact (B) is given a weight which reflects its relative importance to the one above it (E): 0,5.

The third-ranked impact (C) is given a weight which reflects its relative importance to the one above it (B): 0,8.

The process is continued until the importance of each impact relative to the one ranked above it is calculated.

Weightings are then adjusted by multiplying the importance weight of each impact by the adjusted weight of the one ranked above it.

Adjusted weightings are then normalized by dividing each one by the sum of the adjusted weightings.

Normalized scores of each impact can then be added, and the sum divided by the number of panelists to obtain the average weighting for each impact on a percentage scale.

THE APPROACH TO TESTING PROPOSED EVALUATION PROCEDURES

The general approach that was adopted for testing the proposed evaluation procedures can be briefly summarized as follows. A project coordinator was to arrange for the establishment of an evaluation panel comprised of respected and unbiased individuals. The project coordinator would then obtain information on impacts associated with the alternative proposals (using conventional Environmental Impact Assessment techniques and, where possible, shadow-pricing techniques) and provide the panel with this information. Following this, a formal evaluation meeting would be held during which panelists were to employ the selected fractionation technique to obtain a group judgment as to the relative significance of all the impacts that had been identified. The impact values assigned by the panel would then be compared to monetary values, and special analytical procedures would be employed to judge which proposal was more efficient, and to make trade-offs with other criteria.

7 At this stage in the development of the formal evaluation method, the potential for distortion when using this technique was not fully appreciated. A later section (see Impact Evaluation in Chapter 5) presents what is considered a far more reliable scaling technique when it is desired to aggregate individual judgments as to the importance of impacts.

This preliminary approach to evaluating controversial resource allocation proposals involved the accomplishment of the following steps.

Step 1: identifying promising proposals (including the "null alternative" - *i.e.*, doing nothing);

Step 2: listing the costs and benefits (both priced and unpriced) for each proposal that is to be subjected to a formal evaluation;

Step 3: finding "shadow prices" where possible for unpriced costs and benefits;

Step 4: discounting the value of costs and benefits incurred in the future back to present value equivalents (using an appropriate rate of discount) and calculating the present discounted value of each proposal;

Step 5: describing the nature of those costs and benefits for which no shadow prices have been obtained;

Step 6: judging the relative significance of the unpriced costs and benefits on an interval scale;

Step 7: calculating fractional contingency prices for the unpriced costs and benefits;

Step 8: determining which proposal is most efficient (*i.e.*, will yield the greatest net benefit); and

Step 9: judging whether the efficiency gain is worth any adverse distributional consequences or risks to future generations.

It was decided to apply these evaluation procedures to two case studies to collect empirical data to discover whether there were any theoretical or practical difficulties with their application. Of special concern was the efficacy and acceptability of the selected scaling technique, and the possible effects of group interaction on individual judgments when applying the Delphi method in a meeting situation.

Since the principal research interest was the problem of judging the relative significance of impacts on an interval scale (Step 6), the multidisciplinary panel was used to accomplish only this step in the first case study.[8]

CASE STUDY 1

Background

The first case study concerned a sparsely populated and undeveloped area on the Namaqualand coast in the Northwestern Cape. This study was commissioned by the Department of Environment Affairs in 1981, and was conducted under the direction of the Estuarine and Coastal Research Unit of the National Research Institute of Oceanology. The Estuarine and Coastal Research Unit had recently completed a survey of a coastal river/lagoon called Groenrivier. The Groenrivier system is located in a relatively unpopulated and inaccessible area that has considerable potential for two apparently incompatible uses: diamond mining and a national park. At the time of the study (1981-82), the area surrounding the Groenrivier estuary was being utilized for marginal stock farming operations and for primitive camping during holiday periods by the regional population.

The objective of the study was to generate and evaluate a list of resource allocation proposals that would indicate the best approach to future development of the area. The study was therefore essentially a planning problem, but it was known from the outset that there was

8 The remaining steps were accomplished by a small team of researchers.

great potential for conflict and controversy in the management and disposition of the area's resources because of disputes between conservation and diamond mining interests.

The Estuarine and Coastal Research Unit initially defined the study area to include only the estuary, from the mouth to the wetlands above the lagoon, and it was indicated that the purpose of the study was to determine the value of this system and its components in order to decide whether it should be protected from the impacts of general recreation and anticipated surf and beach mining operations. Subsequent discussions revealed that the National Parks Board was formulating a proposal to proclaim a large area around the estuary as a national park, and that De Beers Mining, the principal land-owner in the area, had plans to prospect and possibly mine the surf and beach regions for diamonds. The project coordinator then requested that the boundaries of analysis be expanded to encompass the surf zone and the area being considered for inclusion in the park, and that the purpose of the study be altered. This was agreed to, and the new purpose of the study was formally stated as follows:

- identify and describe potential land-use options in the demarcated area;
- decide which of these options were compatible;
- define suitable resource allocation proposals based on the identified options;
- select the most promising resource allocation proposals as final candidate plans to be fully evaluated; and
- evaluate the final candidate plans for the study area to determine which would be in the overall best interests of society.

The Study

General Approach

The approach to the study was to gather as much relevant data as possible given the time and money available, and analyze these data to develop resource allocation proposals which would then be subjected to a formal evaluation. Much information pertaining to the biophysical and socioeconomic characteristics of the region were available from the recent study by the Estuarine and Coastal Research Unit (Heydorn, 1981) . Because of budget constraints, data collection efforts were limited to the gathering of readily available secondary data and employing two techniques for gathering primary data at a relatively low cost: interviews with knowledgeable persons, and personal observations during field investigations. The data were then organized in a cost-benefit framework, and shadow-pricing techniques were employed in an attempt to estimate the value of certain nonmarketable goods, such as the recreational benefits provided by the natural environment.

The potential land-use options and major resource allocation proposals were chosen by the project coordinator in consultation with a number of people, including local residents, local authorities, managers from De Beers Namaqualand Division, and officials from the Department of Environment Affairs, the Estuarine and Coastal Research Unit, and the Cape Provincial Department of Nature and Environmental Conservation. Land use options were identified through an "Environmental Aspect Analysis", which is concerned with formally assessing the potential utility of an area's resources and identifying suitable land uses. The analysis involved identifying the principal uses to which the area's resources could be put (nine were selected), and then asking a number of environmental specialists and resource managers who were considered familiar with coastal zone resources in South Africa to rate all aspects of the system which were relevant to each use (see Appendix AA). This rating involved comparisons of the condition of the chosen aspects in the Groenrivier area with the condition of these same aspects elsewhere in the country. The following extract from Stauth (1982b:16-19) summarizes the results of this analysis.

Fisheries: The potential contribution of this system to estuarine and marine fisheries is virtually nonexistent. Since there is rarely contact with the sea, plant nutrients are not transported to coastal waters and the estuary cannot serve as a nursery area for larval and juvenile stages of marine organisms. Conditions are also not suitable for aquaculture due to variable salinity, lack of freshwater, and other considerations.

Harbours: There are no sites physically suitable for harbours and anchorages, and in any case this area has very poor access to towns, industries, and transport networks.

Transport: The terrain in the estuarine zone is quite suitable for the construction of roads, railway lines, pipelines, and powerlines. However, there is virtually no demand for these developments. The frequent fog conditions make the zone unfavourable for the establishment of an airport.

Mining: Potential for mining shell, sand and gravel, and potential for salt production operations, is above average. The potential for mining valuable minerals (specifically diamonds) appears to be high.

Forestry and Agriculture: The suitability of the estuarine zone and catchment for forestry operations is nil. The agricultural potential of the estuarine zone and catchment is below average to low. There is no reclamation potential in the estuarine zone, and negligible potential for irrigation projects in the estuarine zone and catchment.

Industry, Housing and Commerce: Socioeconomic demand for new industries, homes and businesses is virtually nonexistent. There are suitable sites for such development; however, the availability of freshwater for industrial and household consumption is totally inadequate. The potential of the estuarine and coastal zone to process and assimilate waste products is judged to be very low.

Water Storage: There are no suitable sites in the estuarine zone for barrage and other water storage schemes, and there are no sites in the catchment for dam construction. In addition, there is little demand for additional water storage capacity in the area to accommodate present uses (small stock and wheat farming).

Recreation and Tourism: The suitability of the estuarine zone for recreational activities is judged to be above average to high. However there is little prospect of attracting a significant number of tourists to the area, at least for the foreseeable future. (As other areas become more congested, it seems probable that this area would appeal to more people.) The capacity to accommodate more recreationists and tourists (without incurring significant congestion effects) is rated above average to high.

Conservation and Scientific Research: The area's potential significance for species and ecosystem conservation is rated as above average to high. While there are no known rare or endangered species, there are several species which are endemic to Namaqualand. In addition, the lagoon is a unique ecosystem and the area contains relatively unspoiled ecosystems which are representative of this part of South Africa and which are presently not protected anywhere else. The

> significance of the area's aesthetic and pristine quality is rated high to exceptional. There appear to be no significant historical or cultural sites apart from potentially valuable strandloper midden deposits. Finally, the importance of the system's ecological functions to any conceivable socioeconomic developments is thought to be low.
>
> Based on this analysis, the most promising management options are to plan developments relating to mining, recreation, and conservation and scientific research.

Even though the agricultural potential of the area was judged to be very low, stock farming was an established land use and important to one major social group, and so was included as a land-use option. The four land-use options that were determined to be viable or of special interest to at least one major social group were

- stock-farming
- general recreation
- national park (which included a marine reserve) and
- diamond mining (principally surf and beach mining).

The monetizable costs and benefits of these land-use options were estimated through an analysis of

- net farm income in the region,
- a survey of recreationists' willingness to pay for recreation benefits,
- a forecast of national park expenditures based on the experience of another coastal park, and
- projections by various experts on the likely scale and results of surf/beach mining operations.

Appendices MM to NN present material which indicates how these analyses were accomplished.

In addition, the Krutilla technique for making adjustments in Cost-benefit Analysis to take account of "dynamic opportunity costs" (see Dynamic Opportunity Cost Valuation in Chapter 3) was applied to calculate a contingency price that would equalize the excess monetary value of surf/beach mining over the national park (see Appendix BB).

Not all of the land-use options were considered to be incompatible. Mining and general recreation were both considered to be compatible with farming, but not with each other; the national park was not considered to be compatible with any of the other land uses. Therefore, three mutually-exclusive resource allocation proposals were eventually selected as final candidate plans and formulated for evaluation:

- mining and farming *vs*. national park;
- general recreation and farming *vs*. national park; and
- mining *vs*. general recreation.

<u>The Delphi Evaluation</u>

The major research objective of this study was to test a specific technique for measuring the interval between impacts, since this is the most crucial task that must be accomplished in order to apply the "fractional contingency price valuation procedure" (see A Proposal for Resolving the

Measurement Problem in this chapter). A variation of the Delphi method was used to apply the "fractional paired comparison technique" (see A Technique for Scaling Impacts in this chapter), and so obtain a group estimate of the relative significance of impacts that could result from the selected resource allocation proposals. The multidisciplinary Delphi panel, which had been selected by the project coordinator, consisted of eight persons and included a sociologist, an ecologist, a geochemist, a biologist, a recreational specialist, a fisheries specialist, a planner, and an agricultural specialist.

In preparation for the evaluation meeting, the project coordinator had identified and defined the external costs and benefits that were associated with each pair of resource allocation proposals that were to be considered, and had produced a document which indicated how each proposal would affect each of the different interest groups (see Box 4.3). Then the Delphi panel met on 26 February 1982 for approximately six hours to determine the relative significance of nonmonetizable costs associated with each alternative.

Due to time and financial constraints, the panel had not received a full impact report on the potential environmental impacts, but the panel had been given written material and a verbal briefing which described the impacts in general terms and explained how various interest groups would be differently affected by the proposals. All of the panelists were familiar with the study area and had read other documentation pertaining to the proposals and their potential impacts.

After the meeting, the project coordinator used the panel's judgments to calculate contingency prices for certain impacts, and then employed the fractional contingency price valuation procedure to determine which of the final candidate plans would be most efficient. Finally, the project coordinator then analysed the relative efficiency and equity effects of the various plans and recommended which proposal would have the greatest social value (Stauth, 1982b)).

The Results

The principal conclusions of the study were as follows.

1. There are 22 farms in the study region and most of the farmers would suffer great nonmonetizable costs if displaced. The farming community place great value on their life style and many families could find it extremely difficult to acquire new farms or take up new occupations, and to adjust to new communities or life styles. Nevertheless, the land in the study area is subject to frequent droughts and has been heavily overgrazed, so that farming no longer appears viable. With declining yields and higher transport costs, expenditure had already overtaken income and farmers were living off subsidies, savings and outside income. There seems to be little prospect that their children would continue farming operations.

2. The Groenrivier mouth is a traditional holiday area for about 300 people. The majority do not want a national park or mining operation established in the area. Local recreationists appear to have few alternative holiday sites open to them. A survey revealed that the principal reasons for visiting the Groen are to be with friends and family in a peaceful and cool setting where one can catch rock lobsters and have a cheap holiday. The average expenditure (exclusive of food and drink) to visit the area was calculated to be R3,70 per person per day, and the additional willingness to pay (the "*consumer surplus*") was estimated to be no more than R3,04 per person per day. Given present utilisation, the total recreational value of the site was calculated to be less than R20,000 per year.

3. The mining potential of the surf zone is unknown but could be very great, particularly as new technology is developed. Forecasts of revenues from surf and beach mining are very problematical. The most optimistic scenario assumed diamonds would be found in sufficient quantity, and the revenue per carat would be sufficiently high, to justify the use of 10 mobile treatment plants to process 4 million cubic metres of ore over a 20-year period. The net present discounted value (at 10%) of this operation was estimated to be R15,148,000.

BOX 4.3

Distributional Consequences of Options

IF GENERAL RECREATION AND STOCK FARMING IS SELECTED -

Benefits:

1. About 300 local residents, as well as their descendants, will keep their traditional holiday area.
2. About 20 farmers and their families will maintain their livelihood and homes.

Costs:

1. Stockholders and about 100 prospective employees of De Beers will lose a potential source of revenue and jobs.
2. A small number of casual visitors will find the natural amenity value of the area diminished by an unsightly campground, degraded lagoon, and overexploited rock lobster resource.
3. Present and future generations of scientists, artists, hikers, general recreationists, and conservationists will lose an area which could help satisfy demand for their various interests.

IF BEACH AND SURF MINING AND STOCK FARMING IS SELECTED -

Benefits:

1. Stockholders and about 100 prospective employees of De Beers will gain a potential source of revenue and jobs.
2. About 20 farmers and their families will maintain their livelihood and homes.

Costs:

1. About 300 local residents, as well as their descendants, will lose their traditional holiday area.
2. A small number of casual visitors will find the natural amenity value of the area diminished by an unsightly campground, degraded lagoon, and overexploited rock lobster resource.
3. Present and future generations of scientists, artists, hikers, general recreationists, and conservationists will lose an area which could help satisfy demand for their various interests.

IF A NATIONAL PARK IS SELECTED -

Benefits:

1. Present and future generations of scientists, artists, hikers, general recreationists, and conservationists will gain an area which could help satisfy demand for their various interests.

Costs:

1. About 20 farmers and their families will lose their livelihood and homes.
2. Stockholders and about 100 prospective employees of De Beers will lose a potential source of revenue and jobs.
3. About 300 local residents, as well as their descendants, will lose their traditional holiday area.
4. A small number of casual visitors will lose the opportunity to visit an "undeveloped" or "unspoiled" area and gather bait organisms and rock lobsters.

4. A national park would conserve important elements of west coast vegetation and provide other benefits, but it is difficult to forecast how many people would visit the park. The costs of developing and operating a national park for the next 50 years were forecast and present value equivalents for these costs were calculated using a 10% rate of discount. The present value of the costs was estimated to be R7,198,000. Since park benefits could not be forecast with any accuracy, it was decided to calculate what the initial year's tourism benefits (from both domestic and foreign visitors) would have to be to offset these costs and equalize the excess monetary benefit of mining (estimated to be R15,150,000, and assumed to remain constant or decline relative to park benefits in the foreseeable future). If one assumes no change in the price of or demand for tourism benefits, the initial year's benefits would have to be R2,254,000. However, if one assumes that the price per user day will increase 5% per annum, and the quantity demanded at the given price will increase 10% per annum, the value of the initial year's tourism benefits would only have to be R191,665 for the park to be more efficient than mining (see Dynamic Opportunity Cost Valuation in Chapter 3, and Appendix BB).

5. An analysis of the nonmonetizable costs and benefits of each final candidate plan was undertaken by a multidisciplinary panel so that contingency prices could be calculated for each nonmonetizable cost. The decision maker could then evaluate these contingency prices for reasonableness and decide which of the mutually-exclusive alternatives would be more efficient.

6. A review of selected contingency prices for each pair of mutually-exclusive final candidate plans was undertaken by the project coordinator, and the following conclusions were drawn:

- a national park would be more efficient than surf and beach mining;
- a national park would be more efficient than general recreational use; and
- general recreational use would be more efficient than surf and beach mining.

Therefore, establishment of a national park would be the most efficient resource allocation proposal.

7. The total social value of the proposals was then evaluated by comparing their efficiency effects to their effects on the distribution of well-being. According to this analysis, the preferred resource allocation proposal was determined to be the national park.

The results of the analysis are described in more detail in Appendix K.

Assessment of the Evaluation

This case study was the first application of the experimental evaluation method, and several lessons were learned from the experience. One general lesson was the importance and difficulty of clearly defining the purpose of the study and the boundaries of the analysis. Several discussions were necessary with the sponsors of the study and other interested parties (particularly proponents of the principal alternatives) to ensure that the study area was properly demarcated and appropriate investigations would be conducted so that the study would be relevant. As a result of these discussions, the boundaries of analysis were considerably extended and the purpose of the study was re-defined. Only then could a proper study plan be devised.

Essentially, the study became an environmental planning problem and in this it was not particularly successful. Inadequate time and attention was given to the search for compromise solutions; the project coordinator accepted the contention (expressed by several protagonists early in the study) that the inherent conflicts between the objectives of a national park and those of a mining company were completely irreconcilable. Subsequent events have proved this was not necessarily true; officials of De beers Mining and the National Parks Board have since commenced negotiations that would not only allow surf and beach mining in the proposed park but would make it a feature of the park. Apparently De beers management eventually decided that tourism may not be incompatible with mining operations, and it may be possible to regulate tourist activity in ways that would be acceptable to both De beers and Parks Board management. This illustrates the importance of aggressively pursuing the search for mutually acceptable alternatives.

The study also revealed the great difficulties involved in defining the proposals that should be subjected to evaluation, and in forecasting the possible consequences of specific actions associated with these proposals. For example, there were many possible mining proposals, and De beers management found it impossible to commit themselves to any specific scenario because so much depended on the results of prospecting, market demand for diamonds, the behaviour of competitors, and rapidly evolving technology. In addition, the value of outputs could vary greatly depending on the size of an ore body, the grade of the ore, the amount of overburden to be removed, and the revenue per carat. Similarly, the ecological costs of beach and surf mining were considered to be highly variable and dependent on a number of contingencies, such as the development of more efficient pumps and machinery. Such considerations, along with the previously mentioned need to continually search for new alternatives, constitute a strong argument for adopting an approach to evaluation that is flexible, emphasizes the quality of subjective judgments, and is based on the principles of political rationality (see Political Rationality vs. Economic Rationality in Chapter 3).

There were several shortcomings in the way that the Delphi panel was selected and utilised, and this could cast doubt on the validity or acceptability of the panel's findings. The panel was small (only 8 panelists were used), and some disciplines and types of expertise that were relevant to the choices involved were not represented. The small size and limited multidisciplinary orientation of the panel meant that the range and content of feedback was restricted, and made it more difficult to assure anonymity of response. In addition, the subjective weighting of impacts is by nature difficult and imprecise, and therefore a larger sampling of weightings for any given impact should result in a more reliable and satisfying average weighting. Furthermore, the smaller the panel the greater the potential for distortions of weightings due to one or two idiosyncratic panelists.

Another major shortcoming was that prospective panelists were identified by the project coordinator alone, employing no systematic procedure, and interested parties were not given an opportunity to endorse or object to the composition of the panel, thus leaving the results of the panel's deliberations open to the charge of bias. For example, of the eight panelists selected, three were academics and the remaining five were employees of the central or provincial government. This could be considered an inadequate representation of society's interests, and may be attributed to the unconscious bias and limited range of professional contacts of the project coordinator.

A shortcoming that proved to be especially troublesome in the application of the fractionation technique was that panelists had not been involved in the identification or definition of the potential environmental impacts. This led to considerable confusion during the Delphi meeting, when it became apparent that panelists had different interpretations of the meaning of certain impact terms and statements. There was also concern that some impacts overlapped or interacted, and this gave rise to allegations of double counting. In addition, although a thorough briefing describing the alternatives and the study area was given at the beginning of the Delphi meeting (and this briefing was illustrated with slides, a film, and other visual aids), and although a document was provided which summarized the more salient points of the environmental investigations, the panelists were not taken on a site visit and no environmental impact assessment had been done; some of the panelists therefore complained that they lacked adequate information to make the judgments that were being required of them.

Finally, the fractionation technique used to weight or scale impacts was later determined by the project coordinator to be suspect because it did not satisfactorily resolve the problem of subjective origins (see The Problem of Scaling Subjective Value Judgments in Appendix C). This problem derives from the fact that there is no objectively determined, common point of reference from which all panelists can scale their judgments as to the degree of significance that can be attributed to each impact. This means that it is theoretically possible for two panels to give the same weightings to a list of impacts when one panel considers all the impacts to be of relatively minor importance while the other panel considers all the impacts to be of extreme importance. Contingency prices based on such weightings would be identical, but this agreement would obviously be spurious.

Other weaknesses or criticisms of the study included the fact that the project coordinator applied the evaluation criteria himself, even though he had no special qualifications, authority or competence to do so, and the intergenerational criterion was not applied at all. (It was only later that the intergenerational criterion was identified and put forward as a legitimate criterion for evaluating resource allocation decisions.)

In spite of these several shortcomings the study stimulated great interest, all concerned parties agreed that the general approach was reasonable, and several of the techniques provided useful information to the decision makers. While it was recognized that the shadow-pricing techniques and some aspects of other procedures were quite unsophisticated in comparison to what has been done in other countries, and certain technical points could be criticized, it was generally felt that the approach taken was appropriate to the level of expertise and financial resources available for undertaking environmental evaluation in South Africa, and was an improvement on the more arbitrary evaluations that characterised current practices. Specifically:

- The Environmental Aspect Analysis proved to be a systematic and comprehensive environmental planning tool.

- The recreation survey, which involved both "travel-cost valuation" and "contingent valuation" techniques (see Shadow-pricing Techniques in Chapter 3) to estimate willingness to pay for present recreation opportunities, provided some indication of the current value of general recreation for the area.

- The analysis of the national park alternative, based on comparisons with an existing park (an adaptation of the "output valuation" shadow-pricing technique), provided some indication of the required value of a national park to make it more efficient than the mining alternative.

- The use of the "threshold valuation" technique (see Threshold Valuation in Chapter 3) helped simplify the decision making problem by producing a specific contingency price that could be evaluated against a list of nonmonetary impacts for reasonableness. In the case of the comparison of the national park and the mining alternatives, this information was supplemented by a range of values, based on a variety of assumptions from which the decision maker could choose and which took account of the changing nature of the terms of trade over time; these values were generated with a computer programme adapted from the Krutilla model (see Dynamic Opportunity Cost Valuation in Chapter 3, and Appendix BB).

- Finally, the Delphi technique permitted the calculation of "fractional" contingency prices (using the fractional contingency price valuation procedure) to simplify the decision making problem still further by providing values for specific impacts, any one of which could then be selected for an evaluation on which to base a decision that preserved the character of the original choice. It was felt that in spite of the problem of subjective origins alluded to above, the values calculated would be useful to the decision maker in analyzing the nature of the choices and trade-offs involved, and in undertaking his own comparative evaluations. In addition, the procedure encouraged analysts and decision makers to explicitly state and re-consider their assumptions during the evaluation process.

The general feeling of the study's sponsors, as well as that of others who were involved in the study, was that the overall approach was conceptually sound and provided useful guidance in helping the decision maker to come to a rational decision. While there was some doubt as to whether the fractional paired comparison technique and the fractional contingency price valuation procedure produced sufficiently accurate results to justify basing a decision on the trade-off between a single impact and a specific sum of money, there was substantial agreement that there was great value in going through the exercise of weighting impacts and (calculating contingency prices for them) because it forced one to be comprehensive, systematic and explicit in one's evaluation of alternatives with very different outputs, and this experience helped one to develop a better understanding of the nature and importance of these outputs.

CASE STUDY 2

Background

In June 1982 Dames & Moore, a firm of consulting engineers, requested the School of Environmental Studies at the University of Cape Town to assist with an environmental evaluation of a proposed granite quarry site in a wine-farming area near Kuilsrivier in the southwestern Cape. To gain approval for the project the client, Hippo Quarries, had to obtain a permit from the Department of Mines and Energy. The client anticipated resistance to the project from local wine farmers, conservationists, and others because of the scenic quality, idyllic rural atmosphere, and historical significance of Cape Dutch buildings in the vicinity of the quarry site. Hippo Quarries had therefore decided to seek the advice of a firm of environmental consulting engineers in order to discover the major problem areas so that action could be taken to improve the general acceptability of the project and thus defuse public opposition. Dames & Moore recommended that the firm authorize a formal environmental evaluation and submit the resulting report in support of their application for the permit.

The study plan called for Dames & Moore to conduct a preliminary environmental study which would describe the proposed project and the affected environment. This study would then be used by the School of Environmental Studies to identify potential impacts and evaluate their relative significance. The client would use this information to redesign the project so as to avoid or mitigate the more important adverse impacts, and enhance the beneficial impacts, in order to improve the prospects that the application would be approved. The environmental report that would accompany the application would indicate what impacts could be mitigated and how this would be done. Finally, by judging the relative significance of all the adverse and beneficial impacts of the project, and calculating contingency prices for these impacts, the evaluation would indicate whether the net benefit of the project to society as a whole was positive or negative.

One of the major lessons learned from Case Study 1 was the critical importance of ensuring that all members of an evaluation panel agreed on the identity and definition of impacts. The project coordinator decided to use the Nominal Group Technique to identify and define the impacts, and the Delphi evaluation technique to estimate their relative significance.

Due to severe time constraints imposed by the client, a full investigation of potential impacts identified by the panel would not be possible. In fact, the impact definition and evaluation meetings were scheduled to be accomplished within a two-day period following a site visit for the Delphi panelists. Nevertheless, there would be opportunities for the panelists to discuss potential impacts with experts on the site visit, and it was felt that the preliminary environmental study produced by Dames & Moore would be useful to the evaluation panel. In any case, this situation provided an opportunity to assess the usefulness of the formal evaluation procedures in cases when there were severe time and monetary constraints for conducting an evaluation.

The project coordinator decided to organize two panels to accomplish the very different tasks of identifying and weighting impacts. These panels were named the "identification panel" and the "weighting panel". The identification panel would be made up of affected parties, relevant experts, the client's planners, and a neutral or nonpartisan group of respected persons whose judgments would likely be respected by all concerned parties. This latter group, in addition to serving on the identification panel, would comprise the weighting panel, which would consist of persons who were considered unbiased but generally knowledgeable about the kinds of issues that would be involved.

The project coordinator informally consulted the client as well as a number of colleagues to recommend suitable members for the two panels. There was little time to assemble the panels, and so consultations and recruitment were done primarily by telephone. A total of 27 persons accepted invitations to serve on the impact identification panel, and 11 of these agreed to also serve on the weighting panel. (Two of the persons who were to be on both panels later had to withdraw.) Members of the weighting panel represented a number of different disciplines that were considered relevant to the study.

The identification panel was to be charged with producing a comprehensive listing of potential impacts from the project. Each impact would be precisely defined, and an attempt would be made to obtain consensus on impact definitions. If any panelist felt that two impacts overlapped or interacted in some way, a new impact definition would be sought that would subsume the others. In this way a list of truly discrete, clearly articulated impacts could be compiled and submitted to the weighting panel for evaluation.

The weighting panel was to be charged with evaluating the relative significance of the impacts to society. This would be done using the same procedures employed in the first case study: panelists would be asked to undertake three iterations of rating the significance of the impacts on a scale of 1 to 7, and then each panelist would do a final rating in order to obtain a ranking of the impacts; the last step would be to apply the fractional paired comparison technique to determine how much more important one impact is than another (see Box 4.2). (Although it had been determined after the Groenrivier case study that this technique did not seem to provide a reliable interval measure of significance, no other technique had yet been discovered that offered any substantial advantages.)

The weighting panel would require the full project description, the preliminary environmental report, a site visit, and a complete list of impacts before the significance evaluations could be done. It was especially important that members of this panel were also on the identification panel so that they would have an opportunity to identify and define impacts to their satisfaction, and would have a clear understanding of the nature and meaning of the impact statements.

The Study

The General Approach

While Dames & Moore initiated the preliminary environmental study, the project coordinator contacted prospective panelists and made arrangements for the meetings. A suitable venue was found on the University of Cape Town campus and the meetings were scheduled on two consecutive days in July 1982. Due to the time constraints, it was not possible to use a more sophisticated (and impartial) technique for selecting panelists, or to fully describe the procedure to affected parties and relevant government authorities, or to obtain general agreement as to the composition of the panels. Members of the identification panel were briefed by telephone as to what would be expected of them.

The weighting panel received a more detailed briefing; first the panelists received a preliminary environmental report, and then they were conducted on a site visit accompanied by consultants to the client who were intimately familiar with the project proposal. In addition to visiting the site of the proposed project, the panelists were taken to an existing granite quarry operation and given a tour of the facility and surrounding area.

The identification panel consisted of 25 people comprised of the following groups:

- affected parties (6);
- environmental consultants (6);
- Hippo Quarries planners (4); and
- the neutral group (9).

The "affected parties group" were representatives of wine farmers, historical societies, and other organizations known to have an interest in the outcome; and who had expressed concern about and given considerable thought to the potential impacts of the project. The "environmental consultants group" were persons who had been engaged by Dames & Moore to undertake special investigations of the affected environment, and were therefore considered knowledgeable about the project and the area. The "Hippo Quarries group" were planners who had designed the project and were also familiar with the area, and who were in a position to point out the beneficial impacts of the project. The "neutral group" (which also comprised the weighting panel) was made up of respected academics and government planners who had been on a site visit and studied the preliminary environmental report, and might therefore identify impacts that would be overlooked by the other groups.

Impact Identification

The identification panel met in a conference room on a weekday morning and were briefed by the project coordinator on the objectives of the meeting and the procedures that would be followed. The principal objective was to identify all possible impacts - both adverse and beneficial - that could result from the quarry project, and to clearly define these impacts and distinguish them from one another so that the weighting panel could then evaluate their relative significance. It was explained that the intention was to list all the possible concerns that anyone might have, so that attention could be given to developing acceptable mitigation measures, and so that a full and proper evaluation could be done. A special search had been made to find persons who could make a meaningful input to the impact identification process, and therefore a diverse group of people had been assembled. The various parties around the room were then introduced and their interest in the project described in very general terms.

It was then explained that the Nominal Group Technique was the procedure that would be used to guide the impact identification process (see Delphi and Nominal Group Technique in Chapter 3). Panelists were told that initially there would be no direct communication between panel members; all questions and comments were to be addressed to the project coordinator, who would then either respond directly or refer the question or ask for comment from another panelist. After the impact identification process was complete, discussion would be allowed to refine the impact definitions and ensure there was clarity on every point. It was emphasized that each panelist would be able to present all of his concerns before the meeting was concluded.

It was at this point that something unexpected occurred. One of the panelists stood up and read a prepared statement in Afrikaans, after which three of the panelists from the affected parties group walked out of the meeting. This planned walkout was to protest the fact that the meeting, about a project which most directly concerned a predominantly Afrikaans community, was being held at an English-speaking university. Fortunately, some of the affected parties group remained so that at least some of the input from this important group was subsequently obtained.

The remaining panelists (who were somewhat nonplussed by the incident) were asked to take a sheet of paper and, working independently and silently, write down all of the impacts (both beneficial and adverse) that could result from this project, defining these impacts as concisely as possible. Panelists were requested to make impact definitions clear and ensure that the impacts on their list did not overlap or interact but were truly discrete impacts.

After the panelists had finished writing, the project coordinator asked a panelist selected at random to read out one impact from those he had listed. This impact was recorded by an assistant on a large flip chart, and then the sheet was torn off and stuck to the wall. Then the next panelist was asked to name one impact from his list, and this impact was similarly recorded and posted. Each impact was assigned a symbol ("B1" for the first beneficial impact, and "A1" for the first adverse impact identified) and the process continued around the room, with each panelist naming an impact that had not previously been listed, or else offering an impact that was similar to one already listed but which differed in some significant way; these latter were treated as alternative definitions to previously listed impacts.

Eventually none of the panelists had any impacts left on their lists which were not already posted (and defined to their general satisfaction). At this point, there were many sheets posted on the walls, most of which listed discrete impacts, but some of which were intended as alternative definitions to other impacts. The project coordinator then opened the floor to discussion by asking the panelists to consider the alternative definitions, and to offer re-wording that would reconcile the differences. In many cases there was clear agreement that one of the definitions was superior, or still another definition was offered and there seemed to be general consensus that it was a better expression of the impact. In other cases, the competing definitions were modified so that they became discrete impacts. Where disagreement persisted, both versions of the impact were accepted as alternative expressions of the impact.

Impact Evaluation

The following day, the weighting panel met in the same room. The project coordinator explained that the original objective of the meeting had been to conduct a thorough Delphi evaluation of the relative significance of two lists of impacts - those which were adverse and those which were beneficial. Unfortunately the list of adverse impacts was so long that it would not be practicable to attempt this task within the time allotted for the meeting, and therefore the objective had been altered.

The intention now was to divide the list of adverse impacts into two more tractable lists: those which could be mitigated and those which could not. These two lists would then be separately subjected to the Delphi procedure of three iterations of rating with feedback after each iteration, followed by a final rating without feedback to facilitate a ranking of impacts. After this, the 10 highest-ranking impacts on each list would be weighted so that the relative significance of the more important adverse impacts could be determined. The two lists would be evaluated in parallel (*e.g.*, while the results of the first rating of the "mitigable" impacts were being processed, the panel would rate the "unmitigable" impacts; and while the latter were being processed, the panel would consider the feedback on the mitigable impacts and undertake a second rating of these). If time permitted, the beneficial impacts would also be rated and scored.

The first task was to agree as to which impacts were mitigable and which were unmitigable. The project coordinator had prepared lists of what he considered to be mitigable and unmitigable impacts based on consultations with Hippo Quarries planners (held after the previous day's meeting), and these lists were presented to the panel. After some discussion, full agreement was obtained and the Delphi procedure was commenced.

The panel managed to accomplish three iterations with feedback for each of the two lists of adverse impacts, and apply the fractionation technique to the top ten impacts, as judged by the third iteration, on each of these lists. Feedback consisted of histograms after each iteration as well as paraphrased comments after the second and third iteration. (The histograms were prepared on overhead transparencies by a data processing team using calculators in an adjoining room, and summaries of comments were prepared and read aloud to the panel by an assistant).

After the third iteration for each list, panelists were presented with a list of the ten impacts with the highest group ratings and asked to use their individual ratings for these impacts to rank them and then apply the fractional paired comparison technique to them. Panelists were also asked to undertake one iteration of rating the beneficial impacts in order to at least give the client some indication of their perceived importance. Finally, the panelists anonymously voted on the question of whether the project should be approved, and supplied brief written statements explaining the reasons for their votes.

The Results

The identification panel identified 45 adverse impacts and 23 beneficial impacts. The list of adverse impacts was subsequently divided into 22 potentially mitigable and 23 essentially unmitigable impacts for evaluation by the weighting panel. The results of the rating procedure were used to rank the ten most significant impacts on each of the three lists so that the proponent, the authority, and other interested parties could see what the major advantages and disadvantages of the project were, and where mitigation efforts should be concentrated. Scores given by the weighting panel to each impact on the two lists of adverse impacts was also provided to give some indication of the relative importance of these impacts. (Scores could not be provided for the beneficial impacts since only one iteration of rating had been done and no ratio-scoring had been accomplished.)

The results of the evaluation were given to Dames & Moore, and further investigations were done by them to determine how the more significant adverse impacts could be mitigated and whether the unmitigable impacts could be avoided or some form of compensation arranged. The project was subsequently redesigned in light of findings from these investigations, and an environmental report was prepared by Dames & Moore indicating what Hippo Quarries intended to do about these impacts, and providing further information pertaining to the unmitigable impacts. This report was submitted to the Department of Mines and Energy in support of the application for a permit. It was thought that the Department might accept the proposed mitigation measures, and stipulate their adoption as a condition for the permit to remain valid.

In spite of these efforts by Hippo Quarries to make the project more environmentally sound, the application was denied.

Assessment of the Evaluation

The Nominal Group Technique and Delphi technique both proved useful and met the client's need to compile and evaluate a comprehensive listing of project impacts within a very short time. In general, participants were satisfied with the techniques and general approach; the major exception was the Afrikaans group, who apparently objected to the venue rather than the procedure itself.

The major weaknesses in this evaluation could be attributed largely to the severe time constraints that were imposed. There was no opportunity to employ an objective technique for identifying prospective panelists, or to secure approval from all concerned parties as to the composition of the panel. In addition, participants were not fully informed as to the nature and purpose of the study, and the reasons why the study was being conducted as it was, and this contributed to the walk-out by some members of the impact identification panel. Finally, very little time was devoted to the critical tasks of refining impact definitions, and clarifying the nature of these impacts and their relationships to one another, and there was no time to conduct an Environmental Impact Assessment before the Delphi weighting procedure was conducted.

Relatively few representatives of those groups who could be adversely affected by the project were invited to serve on the impact identification panel: only six members of the panel could be considered possible objectors to the proposal, while ten could be considered proponents (*i.e.*, representatives of Hippo Quarries and Dames & Moore). In addition, members of the weighting panel were accompanied by representatives of Hippo Quarries and Dames & Moore on their visit to the site and the existing quarry, but not by any spokesmen for the opponents of the project. Such failures to constitute a truly diverse panel and maintain a balance between members of naturally opposing groups lays the study open to charges of bias and favouritism.

The original evaluation objectives were not accomplished, primarily because of the unexpectedly high number of impacts (68) that were identified by the impact identification panel. Because the full lists were not evaluated, it was not possible to calculate contingency prices for any of the adverse impacts. The weighting procedure was applied to only a portion of the adverse impacts, and so it was not possible to evaluate the relative significance of the full list of adverse impacts, and only a single iteration of rating was accomplished for the beneficial impacts.

In retrospect it was a mistake to schedule the meetings of the impact identification panel and the weighting panel on two consecutive days; if more time had been available between these meetings it would have been possible to make more satisfactory adjustments to the evaluation procedure. As it was, great pressure was placed on the project coordinator to revise the programme for the weighting panel in order to produce some useful results. Fortunately, the client was satisfied with the idea of separating the adverse impacts into lists of those which could be mitigated and those which could not, and was not greatly concerned about evaluating the relative significance of all the impacts, and did not require any evaluation of the beneficial impacts.

There were some difficulties with the evaluation conducted by the weighting panel. Although the problem of subjective origins in relation to weighting or scoring impacts had already been discovered (see Case Study 1), no satisfactory resolution to this problem had yet been discovered, but it was felt that group scores (achieved through aggregating individual scores) were still preferable to those of any individual. Some panelists were unhappy with the idea of scoring the top ten impacts on each list as identified by the group as a whole (preferring to score the top ten impacts on their own lists) but they eventually accepted that the group ranking would have to be used to enable a set of impacts to be weighted by all panelists.

The client had hoped that the panel would reach a clear conclusion that the proposal should be approved, but most of the panelists disapproved of the proposal as it existed. Nevertheless, several of the panelists qualified their judgment on the overall acceptability of the project, and indicated they did not feel confident in making a recommendation. Part of the problem was the uncertainty about what the company could and would do to mitigate certain impacts, and some of the panelists indicated that under certain conditions the proposal might be acceptable. It was clear, therefore, that further clarity was needed about the nature and magnitude of impacts, and about the extent and effectiveness of mitigation, before the panel could reach a judgment as to whether the proposal should be approved. In addition, because of the problem of subjective origins, it was not possible to aggregate the values given to the top ten costs and top ten benefits to judge whether the costs exceeded the benefits.

At the end of the evaluation meeting, members of the weighting panel were requested to submit written comments to the project coordinator stating any reservations they had about the impact identification and weighting procedures that had been used. The more salient comments were as follows.

- Some panelists had found the two sessions tiring and were concerned that their performance was affected by the time pressure and the number of difficult judgments required.

- There had been some delays in obtaining feedback, and it was suggested that a microcomputer should be used to produce histograms and other measures of group response more quickly.

- The feedback of histograms and comments was generally considered helpful, but some felt that there was insufficient information exchange on the more complex issues.

- In spite of the efforts to clearly define the impacts, certain impact definitions were still regarded as somewhat ambiguous or overlapping, and it was not always obvious who would bear the impacts.

- The preliminary environmental report was regarded as inadequate because it did not address the specific impacts that had been identified; it was therefore difficult to judge the extent or seriousness of some impacts.

- Panelists did not feel competent to judge whether the proposal should be approved because

  - insufficient information was available on the potential impacts, possible mitigation measures, and alternatives;

  - only ten costs and ten benefits had been weighed; and

  - evaluation criteria had not been explicitly applied.

- Finally, there was a feeling that the panel was not balanced; there were too many academics, particularly from the social sciences.

In spite of these reservations, all but one panelist found the exercise useful and felt that the Delphi evaluation technique had considerable merit and was worthy of being developed further.

DISCUSSION

This chapter has presented the theoretical foundations for developing a strategy and environmental evaluation methodology for resource management, as well as a set of procedures for undertaking formal evaluations. The formal evaluation procedures have been applied to two case studies, and the major lessons learned have been summarized.

The first task was to define the goal and objectives of resource allocation, and to formally identify the evaluation criteria that would be used to develop a resource management strategy and an environmental evaluation methodology. The *a priori* premises which have been presented in this chapter should be acceptable to most people, and the goal of resource allocation that has been derived from these premises - to maximize social well-being over intergenerational time periods - should also be widely accepted. In addition, there should be little disagreement that the evaluation criteria which have been specified here (efficiency, equity and sustainability) are both necessary and sufficient to measure progress towards the goal.

Resource allocation involves decisions at two levels. First it is necessary to decide on a general strategy of resource management; this consists of devising appropriate policies, legislation and administrative procedures to give effect to broad goals or objectives, within which more specific matters of choice can be addressed. Then it is necessary to develop an evaluation methodology which can be applied to the choice between competing resource allocation proposals.

Accordingly, this chapter has first identified some of the considerations which should be addressed in devising a resource management strategy, and has suggested in general terms what form this strategy might take. Specifically, arguments have been advanced to

- proclaim a national conservation policy which would constrain resource allocation options,

- enact environmental legislation which would regulate resource utilization, and

- adopt administrative mechanisms to give effect to the principles and concepts of Integrated Environmental Management.

The environmental evaluation methodology is based on the principles of political rationality, but makes provision for applying a formal evaluation method based on the principles of economic rationality when resource allocation proposals are particularly controversial. While a cost-benefit framework, Delphi procedures, and some kind of scaling procedure all appear to constitute valid and important elements in the development of a method for evaluating controversial resource allocation proposals, several shortcomings were discovered with the evaluation procedures that were applied to the two case studies.

In Case Study 1, because the project coordinator identified and defined the impacts, some panelists misinterpreted impacts or felt that not all the impacts had been identified or defined to their satisfaction. In addition, the ratio-scoring procedure that was utilized did not satisfactorily resolve the problem of subjective origins. Finally, the evaluation criteria were applied by the project coordinator, who may have been perceived as biased in respect of the alternative proposals.

In Case Study 2, the Nominal Group Technique was used to generate a comparatively comprehensive and acceptable list of impacts, but there was still confusion over some definitions, and some impacts appeared to overlap or interact. The same unsatisfactory ratio-scoring procedure used in Case Study 1 was used in Case Study 2, and again there was no formal application of evaluation criteria by unbiased persons. Insufficient time was provided for the impact identification and evaluation process, so that panelists felt rushed and tired, which probably affected the quality of their judgments. In addition, panelists were concerned that insufficient information had been provided to permit informed judgments as to the significance of many impacts.

Other shortcomings of the evaluations done for these case studies were also noted. For example, the brief given to the project coordinator by study sponsors was inadequate in both cases, which resulted in faulty study design. Members of the evaluation panels were selected by the project coordinator, and there were indications that the composition of the panel may not have been considered acceptable by all concerned parties. And there was some skepticism as to the potential reliability of the fractional contingency price valuation procedure.

Nevertheless, other aspects of the general approach to evaluation - including the cost-benefit framework, the application of Delphi principles to a meeting situation which was concerned with evaluation instead of forecasting, and the attempt to systematically and explicitly judge the relative significance of all impacts - were considered fundamentally correct and worthy of further development. In addition, adaptations of certain conventional shadow-pricing techniques in Case Study 1 were generally regarded as appropriate and useful, although there was still some question as to whether they were sufficiently reliable and cost-effective.

The principal conclusion from the two case studies was that it was necessary to more clearly define the objectives and tasks of the evaluation method, and to devise new techniques for accomplishing the key tasks. In addition, a comprehensive testing programme was needed to better assess the reliability and usefulness of the procedures employed, and to adequately demonstrate how well the new method could address a wide range of resource allocation proposals.

CHAPTER 5

THE PANEL EVALUATION METHOD: A DELPHI-BASED APPROACH TO EVALUATING CONTROVERSIAL RESOURCE ALLOCATION PROPOSALS

OVERVIEW

The two case studies presented in Chapter 4 revealed certain shortcomings in the procedures that had been devised for evaluating controversial resource allocation proposals. The lessons learned from these case studies led to the development of new procedures which together comprise a formal method of evaluation called the Panel Evaluation Method.

There are two major parts in this chapter. The first part presents a discussion of the purpose and objectives of the Panel Evaluation Method. This includes a description of the general conditions under which the method should be applied, and the listing of nine specific tasks which should be addressed in a formal evaluation. Then the major objectives of the evaluation method are presented:

- impact identification and definition;
- impact evaluation; and
- application of selected criteria.

After this, three techniques for accomplishing these objectives are presented, and the procedures involved are described in general terms.

Because of the great theoretical and practical difficulties of determining the relative significance of a list of impacts, there is a special discussion of the technique for evaluating impacts: the Significance Measurement Technique. This technique uses procedures which have been designed to greatly reduce these difficulties, but the reliability of the technique needs to be tested, and a hypothesis is formulated for testing.

The second part of the chapter presents a detailed description of how the Panel Evaluation Method can be used to accomplish each of the nine tasks identified in part one. This part also presents the results of a case study which concerned the choice between a marina and a nature area; this case study is presented to demonstrate how all nine tasks are to be addressed. In order to more clearly communicate how the method works, each task is first discussed in general terms, immediately followed by an example from this case study - Case Study 3 - which illustrates how that particular task is to be conducted.

The chapter concludes with an assessment of the effectiveness and potential reliability of the Significance Measurement Technique, and a discussion as to how this important technique might be more effectively employed in future studies.

PURPOSE AND OBJECTIVES OF THE PANEL EVALUATION METHOD

The Panel Evaluation Method has been developed for those situations in which it is determined that a formal evaluation is required. Formal evaluations of resource allocation proposals should normally be undertaken when

- the resources involved are of special concern to one or more social groups,

- there is great disagreement as to which proposed use of these resources is in the best interests of society, and

- the proposals are mutually-exclusive (*i.e.*, there is no possibility of meaningful compromise).

The Panel Evaluation Method is based on the principles of economic rationality, but also takes cognizance of and makes provision for applying the principles of political rationality (see Political Rationality vs. Economic Rationality in Chapter 3). In fact, the object is to employ satisficing behaviour whenever possible, but if political processes cannot resolve conflict, to provide an approach to maximizing behaviour that can be seen to produce rational and unbiased evaluations.

To this end, the Panel Evaluation Method provides for the systematic application of three evaluation criteria - efficiency, equity and sustainability (see Defining Evaluation Criteria in Chapter 3) - and ensures that the evaluation process is logical, rigorous, comprehensive and explicit. The Panel Evaluation Method consists of nine major tasks, which can be summarized as follows:

- Define the terms of reference and devise a study plan.

- Describe the study area.

- Determine which proposals will be fully evaluated.

- Select members of a panel to evaluate the proposals.

- Identify and define the impacts which could result from each proposal.

- Investigate and prepare a report on the impacts associated with each of these proposals.

- Judge the relative significance of each proposal's impacts.

- Identify the proposal which best meets the selection criteria (efficiency, equity and sustainability).

- Analyze the results and prepare an environmental evaluation report for the decision maker and all concerned parties.

Although the principal tasks of the major evaluation techniques used in the method could be accomplished by one person, the procedures that have been developed here for evaluating especially contentious or controversial resource allocation proposals are intended to be conducted by a group of neutral, unbiased persons formed to advise the decision maker as to the relative merits of the proposals under consideration. Group judgments can be useful for several reasons: personal bias, prejudice, and other limitations of the individual are reduced or effectively screened-out; the responsibility of the evaluation is shared; and many people believe, and empirical evidence seems to confirm, that "several heads are better than one" (Dalkey *et al.*, 1972:4; Hill, 1982), and people are therefore more inclined to accept group judgments over any one individual's judgments.

The formal evaluations undertaken in the Panel Evaluation Method are thus to be accomplished by a panel of persons who are considered to be wise, reasonable and impartial, and whose opinions are therefore likely to be respected by the concerned parties. Considerable care must be taken in selecting panel members, and the composition of the panel should always be approved by spokesmen for the major concerned parties.

The panel is guided through the evaluation process by a "project coordinator". This person plays an important role in providing information to the panel and ensuring that appropriate procedures are followed for accomplishing the various tasks. Like the Delphi Method (see

Delphi and Nominal Group Technique in Chapter 3), on which the Panel Evaluation Method is largely based, there is a requirement that certain key tasks be repeated. And, like Delphi itself, the Panel Evaluation Method is characterised by anonymous debate, controlled feedback, and statistical group response.

The three pre-eminent objectives of the evaluation panel are to:

- identify and define the impacts associated with each proposal;
- evaluate the relative importance or significance of impacts associated with each proposal; and
- determine which proposal best satisfies the three evaluation criteria.

A brief description of how these objectives are accomplished is given in what follows. Then a detailed discussion of all nine tasks of the Panel Evaluation Method, illustrated by a case study, will be presented in the next section.

Impact Identification and Definition

The "Impact Identification Technique" is used to accomplish this objective.[1] This technique is aimed at producing a full and comprehensive list of discrete and clearly defined impacts. Although the Nominal Group Technique seemed to be reasonably effective for identifying impacts (see Case Study 2 in Chapter 4), there had been some disagreement as to how impacts should be defined and there was subsequently some confusion over the interpretation of certain impacts. Because of the critical importance of this task, it was decided to allow more time for forecasting impacts and refining the definitions of these impacts. The Impact Identification Technique is therefore based on conventional Delphi procedures, in which a number of iterations are conducted through the post.

Panelists are provided with a briefing document which has been prepared by the project coordinator in consultation with representatives of the major concerned parties. This document is intended to brief panel members on the nature of the alternative proposals, the characteristics of the environment that will be affected, and other relevant information.

After studying the briefing document, panelists are taken on a site visit, accompanied by spokesmen for the competing proposals (and perhaps experts from relevant disciplines), and given an opportunity to ask questions about the proposals. This site visit is intended to enhance understanding of the environmental implications of the competing proposals.

After the site visit, the panel undertakes an iterative procedure (usually, but not necessarily, conducted by post) to identify and define, to the satisfaction of all members, the potentially significant impacts associated with each proposal. This exercise is intended to ensure that the list of impacts is comprehensive, that the impacts are independent or discrete (*i.e.*, do not interact or overlap to any significant extent), and that all panelists interpret the impacts in the same way (see Task 5 in this chapter for a more detailed discussion of this process).

Normally two iterations of impact identification and definition will suffice. In experiments with Delphi to develop a sound information base for environmental decision making and the development of monitoring programmes, Richey *et al.* (1985a:142-143) found that there was little movement toward consensus after the second iteration, and so concluded that it was not necessary to have a second round of feedback and a third iteration. This finding was supported by the results of this research (see Case Studies 3 - 6), although after the second round of feedback individual panelists sometimes requested relatively minor modifications in impact definitions, which then had to be cleared with other members of the panel.

After the list of impacts has been finalized to everyone's satisfaction, the project coordinator engages appropriate experts to investigate the impacts and supervises the

1 For a more detailed description of this technique, see Task 5: Identify and Define the Impacts Which Could Result From Each Final Proposal (in this chapter).

preparation of an impact report. This report is to assist the panelists in evaluating the significance of the impacts.

Impact Evaluation

The "Significance Measurement Technique" is used to accomplish this objective.[2] The Significance Measurement Technique, which can be accomplished through the post or in a meeting situation, is aimed at producing a group measurement of the relative significance of the impacts that have been identified by the Impact Identification Technique. Since the evaluation of impacts was the primary focus of this research, as well as being the most complex and challenging aspect of the Panel Evaluation Method, a description of the procedures used, as well as a discussion of the development and theoretical basis of the Significance Measurement Technique, will be presented here in some detail.

<u>The Rating and Ranking Procedure</u>

After reviewing the impact report, the panelists undertake an iterative rating procedure in which the significance of each impact is rated on a scale of 1 to 7. (In this procedure, "1" signifies "very unimportant", "4" "moderately important", and "7" "extremely important".) The results of each rating are tabulated and "fed back" in the form of histograms to the panel so that each panelist can see how his individual ratings compare with those of the group as a whole.

Generally three iterations of rating (with feedback) are accomplished, followed by a fourth rating (without feedback). The fourth rating is necessary in case any ratings have changed as a result of the final feedback, before panelists rank-order the impacts. This iterative rating procedure is intended to encourage panelists to think more deeply about the implications of the impacts, and to give panelists a better feeling for the relative importance of the impacts. While only two iterations of rating are recommended for impact identification and definition, additional iterations are thought necessary for the impact rating procedure because of the different (and more difficult) nature of the evaluation task. While panelists may be inclined to accept the wording of a forecast so long as the general sense is right, one would expect a greater inclination to change a number that represents a value.

Although, as mentioned above, Richey *et al.* (1985a:142) stated that their results indicated that two iterations of feedback should normally be sufficient, this conclusion was based largely on the observation that there was greater consensus on conceptual issues than there was on factual or "data-based" issues. It appears to be relatively easy to achieve consensus on conceptual issues, when one is dealing with qualitative data and descriptive techniques (such as specifying elements of a monitoring programme, or defining potential impacts). But when one is dealing with quantitative data to resolve factual issues, or using measuring techniques to express value judgments, then it is much more difficult to obtain consensus. While it may be unrealistic to try to forge consensus on factual data - such as the rate of water dilution necessary to avoid some threshold level of change, or the relative monetary costs of independent versus replicate samples (Richey, *et al.*, 1985a:142) - in the case of value judgments it seems worthwhile to spend more effort re-examining and refining measures of significance to obtain a better and more reliable group judgment.[3]

After the final rating, panelists are asked to independently rank-order the impacts according to their social importance. The ranking procedure is obviously greatly facilitated by reference to the final rating scores, and can be accomplished relatively quickly. This step is needed to assist panelists in applying the following ratio-scoring procedure.

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2 For a more detailed description of this technique, see Task 7: Judge the Relative Significance of Each Proposal's Impacts (in this chapter).

3 In fact, the results of the present research confirm that the third iteration of rating produces greater agreement among panelists. For example, in one study in which nine panels rated two or more lists of impacts there was greater consensus (as measured by the standard deviation of response) in over 90% of those cases in which there was a difference between the second and third iterations (see Case Study 4, Assessment of the Evaluation).

The Ratio-scoring Procedure

After each panelist has the list of impacts rank-ordered, he undertakes a ratio-scoring procedure which differs from the one previously described (see A Technique for Scaling Impacts in Chapter 4). This procedure, which is concerned with determining just how much more important one impact is when compared to another (*i.e.*, indicating the "interval", in terms of "importance", between them), permits scaling from a reference point which is thought to constitute an acceptable common point of origin. This means that, after normalizing scores to resolve the problem of variable scale units, it is possible to aggregate the judgments of all the panelists to obtain a group measurement of the relative significance of all the impacts. The procedure is thus designed to overcome the problems of subjective scale units and subjective origins (see The Problem of Scaling Subjective Value Judgments in Appendix C).

Resolving the Problem of Subjective Origins

The incommensurability problem can be resolved by adopting a procedure for scaling subjective value judgments and organizing these judgments in a common, intellectual framework. The problem of variable scale units can be resolved by normalizing scores obtained from the application of some fractionation technique (ratio scoring). This simply involves converting each individual's scores to percentage values so they can be aggregated. But if each person's scale is related to a different base the measurements cannot be aggregated without distortion.

The establishment of an acceptable common point of origin is therefore essential if the data from subjective value judgments by two or more individuals are to be combined in a group judgment that is valid (*i.e.*, accurately reflects the proportional values assigned by each individual). Although frequently assumed, there is no way to establish "common ground" at the upper end of the scale but Edwards (1977:272) points out that less distortion in the aggregation of individual scores will occur if scaling is done from the "least important" item.

This suggests that by asking each individual to first consider comparatively trivial impacts, the group could effectively establish a common point of origin for scaling other impacts. If each individual identifies the lowest-ranked impact which is above his "*threshold of significance*", *i.e.*, the point above which valuation becomes meaningful, then the "*threshold impact*" - the first impact to cross the threshold of significance - may be regarded as the psychological equivalent of a zero point, so that a more objective measurement scale can be derived.

The major difficulty with this suggestion is that there is no way to determine just how near the "threshold impact" is to the threshold itself. For example, if for one panelist the first impact to cross the threshold of significance has a level of significance that is only slightly above the threshold, while for a second panelist the first impact to have any significance is far above the threshold, then when their scale values are aggregated the result will obviously not be an accurate reflection of their combined valuation (and the second panelist may feel quite frustrated).

This problem cannot be completely resolved, but a partial solution would be to ensure that a number of relatively minor impacts are included for evaluation to increase the likelihood that the "threshold impact" is in fact always near the threshold of significance. While this will still not provide a precise way of obtaining a group measurement of the significance of impacts (since there is no way to determine the exact distance the first impact is from the threshold in each case), it is maintained that the psychological distance will normally not vary greatly between individuals (particularly if there are many impacts that are likely to be just above the threshold of significance), so that the first impact above the threshold can be regarded as constituting a reasonable approximation of a common point of origin.

Another difficulty with the "threshold of significance" concept is that the threshold for different lists (*e.g.*, a list of costs and a list of benefits) could conceivably vary a great deal, particularly if one list is much shorter than the other. Then it may not be possible to aggregate group scores given to a list of costs with those given to a list of benefits in order to determine whether a proposal's benefits outweigh its costs. A possible solution to this problem is to ask panelists to select one cost and one benefit which are basically equivalent in terms of significance, and then scale the shorter list in relation to the longer by adjusting the ratio scores of the former in accordance with the linking score which has been assigned.

Mechanics of the Ratio-scoring Procedure

The ratio-scoring procedure that is to be used to evaluate the relative significance of a list of impacts is based on a procedure described in Edwards (1977). In the following description of the recommended ratio-scoring procedure, reference will be made to an example (see Figure 5.1) to illustrate the various steps in the procedure.

- Each panelist refers to the list of impacts which he has rank-ordered from most to least important, using a 7-point scale. Each panelist first reviews the lowest-ranking impacts on his list and places an "x" next to those which, in his judgment, have no real significance to society.[4]

- The panelist will eventually identify the lowest-ranked impact which has at least some significance, and assigns this impact a weight of "10" (Impact F in Figure 5.1). (All impacts below this one have no weight.) This impact is now called the "threshold impact" and it will be used as the standard against which the significance of all impacts ranked above it will be compared.

- The panelist then gives a weight to the next most important impact which indicates the ratio of its importance to the threshold impact. For example, if it is regarded as twice as important as the threshold impact, it gets a weight of "20".

- The relative importance of the next impact up on the list is then evaluated against the threshold impact and a weight assigned which expresses its relative importance as a ratio. For example, if it is three times as important as the threshold impact, it receives a weight of "30".

- The panelist then makes a consistency check to ensure that the resulting ratio of importance between the impacts evaluated thus far are reasonable. In the example used, the third impact should be half again as important as the second (30 to 20). If this ratio does not seem reasonable, the impact weightings must be revised until all the ratios are acceptable.

- The procedure continues, each panelist weighting all impacts against the threshold impact and making continuous consistency checks, until all impacts have been weighted and their relative importance is judged to be reasonable and consistent.

After the ratio-scoring procedure has been completed, the impact weights of each panelist are summed, individual weights divided by the sum, and each result multiplied by 100 to convert scores to a percentage scale. Then the percentage scores of all individuals for each impact are summed, and the total divided by the number of individuals, to obtain a group score or weighting for each impact. The relative significance of the impacts, as judged by the group as a whole, is thus determined. Table 5.1 illustrates how individual scores are normalized and aggregated to produce a group score.

While obviously not perfectly accurate or reliable, this procedure largely resolves the problems of subjective origins and subjective scale units. Standard origins are achieved by relating all measurements to a "threshold of significance", a reasonable psychological datum point for subjective value judgments, assuming that a sufficient number

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4 Panelists are asked to base their judgments on what they assume members of present-day society would feel if they had perfect information on the human condition and were operating from behind a Rawlsian "veil of ignorance" (Daly, 1987; Kneese and Schultz, 1985; Page, 1977).

BENEFITS OF THE WEIR IN RELATION TO THE DAM

IMPACT WEIGHTING FORM

PARTICIPANT'S NUMBER: 6

RANKING	IMPACT SYMBOL	WEIGHTING
1	C	160
2	E	32
3	D	30
4	B	20
5	F	10
6	A	X

FIGURE 5.1 **Illustration of the Ratio-scoring Procedure**

of relatively minor impacts are presented that fall around this datum point for a number of people. Uniform scale units are obtained by simply normalizing scores, which preserves ratio properties but standardizes their expression. The result is that the subjective measurements of several individuals can be combined without excessive distortion to obtain a useful group judgment as to the relative significance of a list of impacts.

TABLE 5.1
Normalizing Group Scores: A Worked Example

Step I: Individual Weighting

	PANELIST P		PANELIST Q		PANELIST R	
IMPACT LETTER	IMPACT WEIGHT	NORMALIZED SCORE (%)	IMPACT WEIGHT	NORMALIZED SCORE (%)	IMPACT WEIGHT	NORMALIZED SCORE (%)
A	500	64,9	10	7,7	150	25,5
B	160	20,8	10	7,7	60	10,6
C	80	10,4	20	15,4	300	53,1
D	20	2,6	35	26,9	30	5,3
E	10	1,3	30	23,1	15	2,7
F	0	0,0	25	19,2	10	1,8
TOTAL	770	100,0%	130	100,0%	565	100,0%

Step II: Group Weighting

	IMPACT						
PANELIST	A	B	C	D	E	F	TOTAL
P	64,9	20,8	10,4	2,6	1,3	0,0	100
Q	7,7	7,7	15,4	26,9	23,1	19,2	100
R	26,5	10,6	53,1	5,3	2,7	1,8	100
TOTAL	99,1	39,1	78,9	34,8	27,1	21,0	300
GROUP AVERAGE WEIGHTING (%)	33	13	26	12	9	7	100

The measurements provided by the Significance Measurement Technique will of course fail to meet the exacting standards commonly found in the natural sciences (*e.g.*, physics). Nevertheless, they may still be considered to represent an improvement over existing approaches to evaluating subjective data, and therefore have great practical value in making improved resource allocation decisions. No scaling technique can ever be regarded as completely accurate, or capable of producing perfectly replicable results. Nevertheless, precision is not essential to the task of providing better guidance for resource allocation decisions; the challenge is to devise and apply methods which appear to give superior results, and in which all concerned parties have considerable confidence. It is suggested that the Significance Measurement Technique represents an improvement over the approach that is now commonly taken in evaluating controversial resource allocation proposals, in which relatively arbitrary judgments are made concerning the relative importance of various impacts. It may be "impossible" to scale impacts accurately, but some kind of scaling is always done - whether consciously or unconsciously - and so there is a need to find more reliable ways of accomplishing this crucial task.

In any case, better decisions will result from simply going through a methodical evaluation procedure, which forces one to carefully examine the potential significance of major impacts and make explicit judgments as to their relative value. Such a process is bound to give practitioners a better feel for the true nature of the trade-offs involved, and provide more carefully considered judgments which can be further deliberated by the decision maker or become the subject of rational debate by concerned parties, and thus provide a sound basis for making more informed and acceptable decisions. An evaluation technique that appears to improve group judgments as to the relative significance of unlike goods, and is seen to be capable of producing replicable results, will have great value even if it is not possible to claim that values have been measured with precision.

Ways to Use the Results of the Ratio-scoring Procedure

The ratio-scoring procedure that has just been described can provide the interval measures needed to calculate fractional contingency prices as previously explained (see A Proposal for Resolving the Measurement Problem in Chapter 4). For example, assume that the excess monetary value of Plan A over Plan B is R15m, but there are ten unpriced adverse impacts associated with Plan A (all or some of which may be foregone opportunities associated with Plan B). In addition, assume that there are no unpriced adverse impacts associated with Plan B. Assume further that the significance of each of Plan A's ten impacts has been judged relative to each of the others, and it is determined that one of these, Impact X, constitutes 20% of the total impact of all ten taken together. Finally, assume that a reliable shadow price has been determined for Impact X, and this amounts to R4m.

Then, even though one does not have shadow prices for the other nine impacts, it is possible to determine whether Plan A is more efficient than Plan B. Assuming that the relative values of the ten impacts have been calculated correctly, the proportion of the contingency price that can be ascribed to Impact X is R3m (R15m x 20%). This means that if the value of Impact X is judged to be less than R3m, Plan A will be more efficient than Plan B; if it is judged to be greater than R3m, Plan B will be more efficient than Plan A. Since the shadow price for Impact X is R4m, then Plan B is actually more efficient than Plan A.

Even if it were not possible to obtain an acceptable shadow price for any of the ten impacts, it would still be easier to evaluate the contingency price for a single impact than the contingency price for all ten impacts taken together. In this case, one could simply select a particular impact, the value of which is relatively easy to conceptualize in monetary terms, and evaluate its contingency price for reasonableness.

The results of the ratio-scoring procedure can be used in other ways to judge the efficiency of a proposal. For example, if one of the impacts can be confidently related to a monetary value[5], it would be possible to calculate the monetary value of each of the other impacts, since their relative values have been determined. The total estimated monetary value of the impacts could then be added to the present discounted value of the proposal to judge whether the net value of the proposal was positive, or whether it was greater than that of another proposal.

Alternatively, if all the monetizable impacts have been scaled along with the nonmonetizable impacts (or if the net present discounted value of the proposal has been weighted as one of the impacts), there is no need to calculate fractional contingency prices or convert impact weights to monetary values: the efficiency determination can be made directly by simply summing the weights assigned to costs and benefits to see whether costs outweigh benefits or vice versa. Theoretically, there is no need to use monetary measures in making efficiency determinations (Samuelson, 1973:6), and perhaps it is not necessary to attach so much importance to estimating monetary values when what is really wanted is a measure of the relative significance of outcomes.

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5 This could be done, for example, if one of the impacts is expressed in monetary terms, such as: "The cost of water would increase to 30 cents per cubic metre". If water consumption is known, the extra cost of water could be calculated to determine a monetary value for this impact.

The Need to Demonstrate Reliability

Of special interest is the question as to whether the judgments produced by the recommended ratio-scoring procedure can be demonstrated to be valid or reliable. Since it is not really possible to assess "*validity*" in matters concerning subjective value judgments (who is to say whether a value that is held is "correct" or not?), emphasis in this study was on assessing the "*reliability*" of such judgments by determining whether the judgments of independent groups were replicable or not. In three of the case studies in which the Panel Evaluation Method was applied, an attempt was made to assess the reliability of the Significance Measurement Technique. This was done by having two or more groups conduct independent evaluations, given the same information and using the same procedures, and then determining the correlation coefficient of weighting scores given to identical lists of impacts.

The hypothesis that was formulated for testing in these cases was that <u>if two panels are asked to evaluate the relative significance of a list of impacts from some action, the group judgments of one panel will be highly correlated with that of the other, provided that certain conditions are met</u>. The conditions specified as being sufficient (though perhaps not all necessary) were as follows:

- the panels are large enough to encompass a broad spectrum of knowledge and opinion;
- the panels are similar in that the same basic disciplines are represented on each panel;
- none of the panelists on either panel have any vested interest in the issue which is being evaluated;
- both panels have an opportunity to study the proposal and visit the area that will be affected;
- panelists on both panels are given an opportunity to add to the list of impacts, and redefine impacts, until everyone is agreed as to the identity and definition of potential impacts;
- both panels are provided with the same data (environmental reports) pertaining to the impacts;
- both panels follow the same procedure for "scaling" or judging the relative significance of impacts; and
- the procedure for scaling impacts involves several iterations of evaluation, with anonymous debate and controlled feedback between iterations, to encourage a thorough, rigorous and unemotional evaluation.

Application of Selection Criteria

The "Criteria Trade-off Technique" is used to accomplish this objective.[6] This technique is applied after the Significance Measurement Technique has been completed, usually immediately after the ratio-scoring procedure, and is done in the following way.

Each panelist completes a "*personal evaluation statement*" using a prescribed format in which he systematically compares the proposals in terms of the three evaluation criteria (efficiency, equity and sustainability) and identifies the proposal which he considers to be in the best overall interests of society. In the course of completing the statement, the reasoning behind all judgments is made explicit and clear.

The personal evaluation statements are intended to indicate how each of the panelists would make the decision as to which resource allocation proposal should be selected, and reveal the

6 For a more detailed description of this technique, see Task 8: Identify the Proposal Which Best Meets the Selection Criteria (Efficiency, Equity, Sustainability) (in this chapter).

principal arguments favouring that decision. Box 5.1 illustrates a recommended format for guiding the panelist in preparing a personal evaluation statement.

BOX 5.1

Procedure for Completing a Personal Evaluation Statement

Please compare the projects in terms of the following criteria.

1. EFFICIENCY EFFECTS:
WHICH PROJECT YIELDS THE GREATER NET BENEFIT TO SOCIETY?
- Will the benefits outweigh the costs for both projects?
- Which project will have the greater net benefit?
- How much greater is the anticipated net benefit of one project compared to that of the other project?

2. EQUITY EFFECTS:
IS THE DISTRIBUTION OF BENEFITS AND COSTS FAIR FOR BOTH PROJECTS?
- For each project, which groups will benefit, and which groups will be worse off?
- How significantly will the well-being of each group be affected by each project?
- Is it likely that those who bear significant costs from either project will be adequately compensated?

3. INTERGENERATIONAL EFFECTS:
HOW WILL EACH PROJECT AFFECT THE WELL-BEING OF FUTURE GENERATIONS?
- Should the well-being of future generations be taken into consideration?
- Which project would future generations prefer?
- How important are any special risks, irreversible costs, or suspected secondary impacts arising from either project, likely to be for future levels of well-being?

4. TRADE-OFF OF CRITERIA:
WHICH PROJECT IS IN THE BEST INTERESTS OF SOCIETY?
- Which project should be selected?

(Explain answer in terms of the three evaluation criteria which you have just applied above.)

The purpose of the formal, written evaluation statement is to ensure that the panelist arrives at the judgments which are required in a systematic manner, and to clearly indicate to the decision maker and other readers the values and logic that support these judgments. There are four steps in completing the personal evaluation statement.

- First, a judgment is made as to whether a given proposal is truly efficient or not (after unpriced impacts are considered), and whether it is more or less efficient than a competing proposal. (This judgment will obviously be made easier if the panelist has previously evaluated the proposals using the Significance Measurement Technique.) A short written statement (perhaps one paragraph) is to be prepared which clearly states the reasoning behind this judgment.

- Then the panelist considers the distributional consequences of the proposals, and judges how fair or equitable these consequences would be. This is done by systematically identifying the groups that will be differently affected by the proposals, then indicating in another short statement how these groups will be affected, how significant the effects are likely to be, and whether inequities can or are likely to be rectified.

- Next the panelist considers the intergenerational effects of the proposals, and again writes a brief analysis of the implications for future generations; this would include a declaration as to whether the panelist feels that the well-being of future generations should even be considered, and if so how important the impacts are likely to be to future generations, and how seriously this situation should be regarded by the present population.

- Finally, the panelist evaluates the overall performance of the proposals in terms of these three criteria, and writes a concluding statement which names the preferred proposal and explains how trade-offs between the criteria were made in arriving at this recommendation.

If more than two proposals are being evaluated the problem of trading-off criteria can be greatly compounded. For example, it is possible that different proposals will be judged superior for each of the three evaluation criteria. In this case, it may be desirable to employ a more formal or structured approach to identifying the proposal which best satisfies all three evaluation criteria; such an approach is presented in Box 5.2 and Figure 5.2.[7]

BOX 5.2
Example of the Recommended Trade-off Procedure

Assume that the evaluation criteria have been applied to three proposals with the following results:

- Proposal B is the most efficient (i.e., has the highest net benefit);
- Proposal A is the most equitable (i.e., has the fairest distribution of costs and benefits); and
- Proposal C is the most sustainable (i.e., has the most favourable intergenerational consequences).

Then the three criteria may be traded-off using the following process of elimination. (Reference should be made to Figure 5.2 which illustrates the procedure.)
The efficiency/equity trade-offs will normally be made first because for most decision-makers the welfare of present generations comes first. The outcome of that decision will then determine the nature of the second trade-off, which concerns the interests of future generations.

In the example given, if B is preferred to A (because the efficiency gain of B is considered to outweigh the equity gain of A), then an efficiency/intergenerational trade-off must be made between B and C. Then if the efficiency gain of B outweighs the benefits of C to future generations, B will be selected. However, if the gain to future generations offered by C outweighs the efficiency gain of B, then C will be selected.

By the same token, if A is preferred to B during the efficiency/equity trade-off (because the distributional consequences of A had been judged to be more advantageous than the efficiency of B), it would then be necessary to choose between A and C. In this case, if the equity gain of A is thought to be more important than the welfare gain to future generations offered by C, then A would be selected. Alternately if benefits to future generations offered by C are thought to outweigh the equity improvement offered by A, then C would be selected.

This section has presented a brief description of the three principal techniques associated with the Panel Evaluation Method. The next section presents a discussion, illustrated by a case study, of each of the nine tasks that the method has been designed to accomplish.

THE EVALUATION TASKS

The Panel Evaluation Method consists of a series of prescribed tasks for conducting a formal evaluation. This section explains how each task is to be accomplished, and illustrates each task with an example from a case study.[8]

7 Although there are many other ways to approach multiple criteria decision making that are more sophisticated and may be more satisfying to the theoretician (see Appendix D), these may not always be regarded as appropriate in the relatively unsophisticated decision making environment in many areas in South Africa and other parts of the Third World.

8 After the description of each task, the relevant case study material will appear in a different type face.

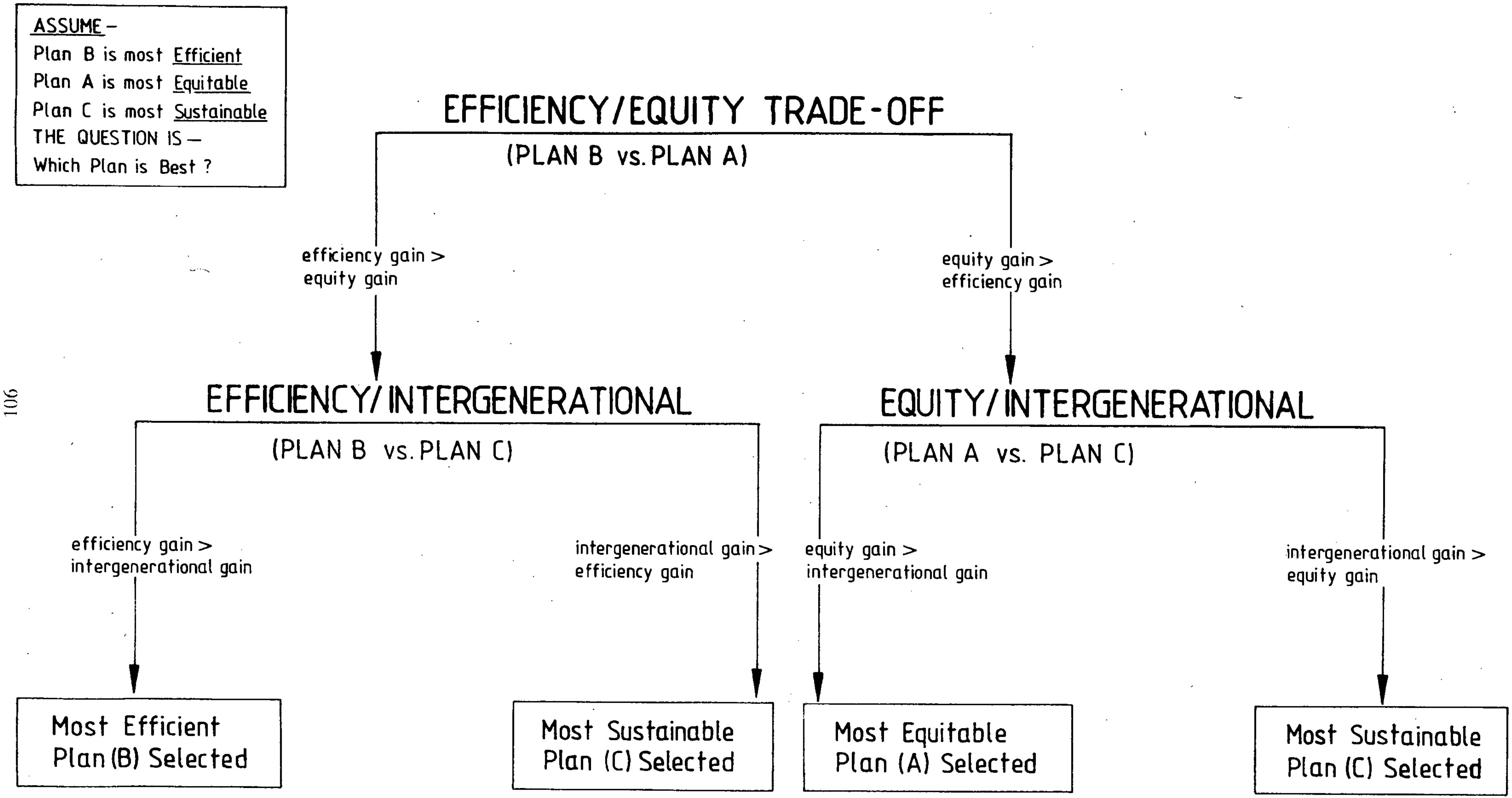

FIGURE 5.2 **Trade-off Diagram**

The research effort that is required to accomplish each task will obviously vary from case to case. In order to adequately explain the full array of procedures that comprise the method, the following discussion will proceed on the assumption that the consequences of a decision are important enough to justify a substantial expenditure of time and money in applying the method.

The first application of the Panel Evaluation Method was an evaluation of two competing and controversial proposals for the Rietvlei-Milnerton Lagoon area near Cape Town. During the course of this study, a decision in favour of one of the proposals was made and the study was no longer needed for its original purpose. It was, however, decided to complete the study in order to demonstrate the major features of the Panel Evaluation Method. Because there was no longer any need or justification for expensive data collection efforts, an impact report that was in preparation for the Delphi panelists was not completed. Nevertheless, all of the other steps of the general procedure were completed.

In order to test the replicability of the Panel Evaluation Method, the Delphi panel was divided into two groups which separately evaluated the proposals using the same procedures and data. The results of this test are presented at the conclusion of this section.

Task 1: Define the Terms of Reference and Devise a Study Plan

The first task for the project coordinator is to determine the scope of the study and the boundaries of analysis, and then to devise an effective study plan. The study area must first be delineated, and the scope of the study clearly defined, in consultation with proponents of the various proposals and with decision makers.

The Terms of Reference

The project coordinator will usually be given some sort of brief which indicates the general area to be studied, the nature of the proposals under consideration, persons who should be consulted, the resources available for the study, and any legal, financial, or policy constraints which may exist. Very often the party initiating the study will not have formed a clear idea of precisely what is wanted, and so will not have adequately conceptualized the scope of the study or the terms of reference. The initial brief may therefore require considerable clarification, and may also require substantial modification before the study begins. In addition, the general terms of reference could very well change during the course of the study, as a result of obtaining new information or the development of new circumstances.

The brief may either specify that certain proposals be evaluated, or that a general resource management plan be devised for the area in question. Detailed descriptions of proposals will normally not be immediately available, but proponents of the proposals should be consulted at an early stage to gain a good understanding of the possible actions involved and the motivation behind them. This will facilitate good study design, and ensure that investigations will be relevant. In the case of resource management plans, the general options which appear to be available should be listed and possible conflicts identified.

The principal figures who should be consulted initially are persons who are motivating for some action (*e.g.*, "developers" or some local authority), and persons who have been entrusted with some responsibility for management of the area (*e.g.*, the relevant government officials). This is necessary in order to attain a better understanding of what is wanted by the parties initiating the study, and of what is possible according to the regulating authorities. All authorities with some jurisdiction should be asked to indicate any constraints which could affect existing or potential proposals, or otherwise restrict the scope of the study. It is advisable to have several exploratory discussions with proponents and relevant officials before the boundaries of analysis are delineated in order to ensure that the scope of the study and the terms of reference are clearly understood and acceptable.

Unfortunately, because the ultimate "decision makers" are often busy people with little time or inclination to talk to researchers, the project coordinator will usually have limited access to these key figures and it may therefore be difficult to clearly define the proposals and to assess what will be considered possible or acceptable. Nevertheless, considerable effort should be given to engaging the interest of these influential persons, securing their cooperation and general approval of the study, and cultivating a good working relationship with them and their staffs.

It is also desirable to consult with representatives of some of the affected parties at this early stage in order to acquire a better understanding of the possible conflicts that could arise, and possible compromise solutions to these conflicts. Persons to be consulted on the proposals (and possible alternatives) would include community leaders, respected officials, representatives from all affected parties, and experts from relevant disciplines. Because the decision maker will probably have little time to personally investigate or fully consider the various options and all the ramifications from any action, the project coordinator has a special responsibility to hear as many points of view and obtain as much data as possible, and then present these in a balanced and coherent way.

The study area should be tentatively defined - with the aid of proponents, authorities and others familiar with the general region - by reference to geographical features, ecological characteristics, and socioeconomic considerations, with particular attention to the latter (since the ultimate object of the analysis is to evaluate the effect of alternative proposals on social well-being). The boundaries of analysis may require redefining when specific opportunities or problems are identified, and it should be anticipated that special analyses of regional, national, and even international implications may be necessary. This will normally involve simply extending the boundaries of analysis as required to ensure that all relevant considerations are fully assessed, but there should be a principal "study area" on which the analysis remains focused.

The resources available for the study will normally be specified by the organisation commissioning the study. The project coordinator should obtain a clear, written statement as to the study objectives, general terms of reference, financial and material support, staffing arrangements, time allowed for the study, and any special conditions which have been stipulated. This written statement will serve to ensure that investigations are always relevant and that there will be no misunderstandings as to the resources or time available and what is expected in the final report.

The project coordinator should then familiarize himself with all supporting facilities which are to be made available before he drafts a general study plan. A provisional budget and timetable should be prepared as soon as possible and reviewed with the initiating authority to assess whether the resources provided and the time allowed appear to be adequate.

Finally, an official memorandum should then be transmitted to the principal parties formally stating the scope of the study, the boundaries of analysis, and the general tasks to be undertaken, to ensure that all concerned parties are in agreement as to what the objectives are, what specific area is of interest, and how the study will be conducted.

<u>The Study Plan</u>

After examining the study area and undertaking a brief investigation of the present and potential uses of the area's resources, a detailed study plan is prepared. Data collection and assessment techniques need to be selected, research staff appointed and briefed, and budget and timetable finalized. The study plan will outline the general nature of the specific investigations to be conducted. These investigations are scaled to suit the probable importance of the resource allocation decision and the availability of time, money and manpower to the researchers. The level of investigation required is to be governed by the project coordinator's perception of the following conditions:

- the degree of definition or certainty pertaining to the proposed actions;
- the possible social significance of the outcomes;
- the availability of reliable data;

- the cost of data acquisition;
- the resources available; and
- the degree of detail and refinement needed for evaluating alternatives.

Emphasis will usually be on assessing the implications of alternatives that have already been identified and are being seriously considered by resource owners or managing authorities, but an attempt should also be made to identify new alternatives and suggest how the initial proposals can be improved.

The study plan should be flexible in order to cope with unforeseen contingencies. Implementation of specific elements of the plan will depend on circumstances as they develop. It is not always possible to specify all the actions, or clearly define the nature of each action, in the early planning stages of a proposal. There are generally great uncertainties associated with the original proposals, so that proposals tend to evolve as they progress, and are often substantially modified as new information or technology becomes available. In addition, the potential effects of a proposal that has been modified only slightly may differ dramatically from those of the original proposal. If the impacts and their magnitude are likely to require reassessment because of project design changes, then expensive and time-consuming assessment and evaluation techniques may be impractical. In these cases, the study plan should outline a flexible, "layered" approach to the investigation, incorporating a range of possible techniques for gathering and assessing data, and to be implemented or not according to the circumstances that arise.

The Rietvlei Case Study: The General Terms of Reference and the Study Plan

The Terms of Reference

In early 1982, the Cape Department of Nature and Environmental Conservation was investigating the desirability of proclaiming a vlei-lagoon system in the Milnerton area north of Cape Town as a "nature area" to preserve its recreation, conservation, and education potential. This area, known as Rietvlei (see Appendix CC), was owned by Milnerton Estates, which had plans to develop the area into an inland marina and was seeking zoning approval for this development. In June 1982, officials from the Department of Environment Affairs and the Estuarine and Coastal Research Unit of the National Research Institute of Oceanology suggested that the School of Environmental Studies at the University of Cape Town undertake an environmental evaluation of these two general proposals.

After a familiarization visit to the Rietvlei area and preliminary discussions with officials from the Cape Department of Nature and Environmental Conservation and Milnerton Estates, the project coordinator arranged meetings with officials from the Department of Environment Affairs and the Estuarine and Coastal Research Unit to determine the specific objectives of the study and to obtain background information for planning the study. Since senior officials of both Milnerton Estates and the Cape Department of Nature and Environmental Conservation stated adamantly that they had no interest in reaching some form of accommodation, and the proposals appeared to be mutually exclusive, it was decided that efforts to find a compromise solution would be futile. The proponents were therefore asked to each develop a preferred version of their preliminary plan and submit it for a comparative evaluation.

The major purpose of the study, it was decided, was to recommend which of these two proposals would be in the best interests of society, and it was suggested that the best way to do this would be to forecast the effects of each proposal and then determine the relative social value of these effects. When questioned as to the meaning of "society", officials with the Department of Environment Affairs indicated that the principal populations of concern were the residents of Cape Town *and other communities in the Cape Peninsula area, although it was recognized that the community of Milnerton would be most directly affected. In addition, certain features of the area were of national and even international interest; for example, the vlei-lagoon system had the only golf links in the country, and the wetlands were considered an important habitat for water birds that migrate from the northern hemisphere. Finally, future populations of the greater Cape Town area had to be considered, particularly since the vlei-lagoon system was unique in the region and constituted one of the few large, completely undeveloped areas remaining in metropolitan Cape Town.*

Further meetings were then held with officials from the Cape Provincial Department of Nature and Environmental Conservation and Milnerton Estates to enlist their cooperation and obtain more information for planning the study. It was noted that the Cape Provincial Department of Nature and Environmental Conservation had done very little planning beyond the general conceptualization stage, while Milnerton Estates had already completed engineering feasibility studies and a financial viability study of several possible marina development schemes. The extent of Milnerton Estates property holdings in the area, and the exact area of interest to the Cape Provincial Department of Nature and Environmental Conservation for inclusion in the nature area, was determined during these meetings. The initial brief by the Department of Environment Affairs and the Estuarine and Coastal Research Unit had indicated that only Rietvlei itself would be affected by these proposals, but discussions with the proponents indicated that Milnerton Lagoon and the mouth of the Diep River would also be involved (see Appendix CC).

Several other persons were then consulted who were in a position to provide information pertaining to the study. These included the City Engineer for Milnerton; a civil engineer with the engineering firm that had conducted the feasibility studies for Milnerton Estates; a planner/consultant who had done the financial viability studies for Milnerton Estates; an estuarine ecologist who had done several studies of the vlei-lagoon system; an ornithologist familiar with the area; and the Director of Metropolitan Planning. Several reports from past studies were obtained from the above sources.

The responsible authorities were asked to indicate any specific legal, financial, or policy constraints which could affect either of the preliminary proposals, or any variations of these proposals, or any aspect of the study as envisaged, and none was indicated. The Department of Environment Affairs agreed to provide R22,000 to finance the evaluation study over a one-year period. The study was to be conducted under the auspices of the Estuarine and Coastal Research Unit, but office, secretarial, and other facilities were to be provided by the School of Environmental Studies at the University of Cape Town. A provisional timetable and budget were prepared by the project coordinator, and although these were accepted, all parties agreed that the time allowed and the financial resources provided appeared to be inadequate. Of particular concern was the fact that it would not be possible to produce an adequate Class 1 Environmental Impact Assessment with the available resources (see Appendix H for a discussion of Class 1 assessments).

Nonetheless, it was decided to pursue the study with the limited resources available and rely on secondary data and inexpensive data-gathering techniques. After considerable discussion, the sponsoring authorities agreed that if at the end of the study period it was decided that insufficient data had been collected to permit a satisfactory evaluation, application could then be made for further funds and an extension of the study period. It was anticipated that this would indeed be possible, but if funds were not available, then the study would be used to simply demonstrate and refine the general Delphi evaluation procedure. A memorandum was then *drafted and signed by the project coordinator which outlined his understanding of the objectives of the study, the support that would be provided, the boundaries of the analysis, the nature and timing of reports, and other details of the agreement.*

The Study Plan

Preliminary investigations revealed that a considerable amount of secondary data pertaining to Rietvlei was readily available since several conservation organisations and university departments had undertaken studies of the vlei-lagoon system over the past several years. In addition, several studies had been done on the technical and financial viability of the marina project proposal, but these studies were nearly 10 years old and some of the material would require updating. Unfortunately, very little work had been done on planning the nature area proposal, apart from establishing the proposed boundaries and developing guidelines for how the area would be managed.

Since limited time, money and manpower were available to collect primary data, it was decided to concentrate on collecting secondary data, and then designing low-cost primary studies if these were deemed absolutely necessary. The Panel Evaluation Method is designed to be adaptable to all levels of research needs and available resources, and a major objective of the study was now to see whether two panels could produce replicable results and feel satisfied with the quality of their judgments without receiving a proper Class 1 impact report on the proposals.

The general approach adopted for data collection was to interview persons who had special knowledge or expertise related to the area or to the two proposals, and to gather all published and unpublished reports and other documents which were considered relevant. Then, if further studies were required, these could be designed and undertaken by supervised students. The type of studies envisioned included investigations of the conservation needs of the western Cape, the recreational needs and desires of metropolitan residents, assessments of the amenity value of the vlei-lagoon, more accurate measurements of the ecological productivity of the area, and estimates of the possible magnitude of specific impacts associated with the projects (e.g., noise, loss of bird habitat, and potential flood damage).

The formal study plan consisted of the following steps:

- *Review the literature pertaining to environmental impact assessment and evaluation methodologies.*

- *Go on familiarization visits to the study area, making notes of personal observations and listing further data needs.*

- *Gather and review all available background documents (including maps, aerial photos, historical records, reports, engineering notes, and minutes of meetings).*

- *Compile a list of interested, knowledgeable or concerned parties with whom to consult, and then interview these people.*

- *Investigate, in consultation with the proponents, the possibility of redesigning the preliminary proposals to find more acceptable alternatives for consideration (perhaps even a mutually-acceptable proposal), and devise a procedure for selecting the "final proposals" (those proposals which would be subjected to a detailed evaluation).*

- *Select a panel of evaluators to assist in identifying and defining impacts associated with the final proposals (and later to evaluate the relative significance of each proposal's impacts and to recommend which proposal would be in the best interests of society as a whole).*

- *As resources permit, conduct special studies into the impacts of each project and issue an impact report for the edification of panelists and other interested parties.*

- *Convene a Delphi meeting to undertake a formal evaluation of the projects and make recommendations.*

- *Issue an Environmental Evaluation Report.*

Task 2: Describe the Study Area

The study area should be formally described in order to attain a more intimate knowledge of its principal features, gain familiarity with the existing situation, determine the availability of existing data, and discover possible problems or opportunities which bear investigating. This will improve the prospects that subsequent investigations will be relevant and that potential solutions to problems will be discovered.

Description of the study area should be based on personal observations, discussions with knowledgeable persons, and an investigation of secondary sources. The resulting document, which should be illustrated with photographs, maps, and drawings, will serve as a convenient reference source during the course of the study, can be used to quickly brief others participating in the study, and will be needed in the final report to "set the scene".

The study area can be described in a formal report that can be used as a briefing document for Delphi panelists, using the following format:

- name of area;

- location in relation to well-known features (preferably illustrated with maps or drawings);

- general description (shape, extent, etc.) and precise boundaries;

- nature of surrounding area;

- land ownership;

- present character and uses; and

- general considerations.

The study area report will be used to guide further investigations and to brief participants in these investigations.

<u>The Rietvlei Case Study: The Study Area</u>

After making several visits to the Rietvlei area, reviewing reports and other documents, and holding discussions with long-time residents and other persons who were intimately familiar with or had intensively studied the vlei and lagoon, a brief description of the study area was compiled as background information for those persons who would be involved in the study or interested in its outcome. The study area description was eventually summarized on a single page and, along with two aerial photographs of the area, included in the briefing document. A reprint of this document, which also included descriptions of the study and the proposals, is found in Appendix CC.

Task 3: Determine Which Proposals Will Be Fully Evaluated

The objective of this task is to ensure that all alternatives for meeting the purpose and need of the proposal(s), as well as competing uses of the area's resources, are identified and adequately considered, and to select and define the "final proposals" - those proposals which appear to be of greatest interest and which will be subjected to the Impact Identification Technique and Significance Measurement Technique. This task is accomplished in two distinct steps:

- generating alternative proposals for consideration, and
- selecting those alternatives which are to be subjected to the Delphi evaluation.

The number of possible resource allocation proposals could be very high. It is obviously not practical to conduct a thorough evaluation of each possible proposal, and so it is necessary to adopt a procedure for selecting two or three proposals which will be subjected to the full evaluation procedure. This search for alternatives may sometimes result in the discovery of a compromise proposal which is acceptable to all concerned parties, in which case a formal evaluation procedure will not be required. If, however, different interest groups still favour alternatives which are mutually exclusive and no accommodation is possible, the proponents of incompatible proposals can be asked to submit a single variation of their favoured preliminary proposal to be subjected to the full evaluation process.

In order to facilitate discussion of possible alternatives, it is important that the goals and constraints of the evaluation have been clearly stated at an early stage, and that the three evaluation criteria (see Defining Evaluation Criteria in Chapter 4) are fully considered when generating alternative proposals and selecting final proposals:

- is the proposal efficient (will benefits outweigh costs)?;
- is the proposal equitable (will costs and benefits be distributed fairly)?; and
- is the proposal sustainable (will benefits continue to exceed costs for future generations)?

The generation and selection of alternatives to be evaluated should be a dynamic, iterative process that employs techniques and procedures which will stimulate ideas, promote cross-fertilization and understanding, and encourage consensus on what the issues are and how they might be resolved. The object of the process is to define problems and opportunities, identify data needs, and explore possibilities for compromise.

The process begins, according to the general Integrated Environmental Management procedure (see The Concept of Integrated Environmental Management in Chapter 4 and Appendix H), with discussions between the proponent of some action and the authority responsible for granting approval for the action to be implemented. If the action is likely to be controversial, the proponent should initiate discussions with potentially affected or concerned parties in the proposal generation stage, *i.e.*, before developing a specific version of the proposed action that will be submitted for assessment. This search for potential mitigation measures and alternative proposals continues and becomes more formalized, systematic and focussed in the assessment stage of Integrated Environmental Management through the scoping procedure: scoping makes it possible for all concerned parties to participate in identifying the environmental considerations that need to be addressed, focus on the significant issues that are involved, and identify realistic suggestions for solving problems, meeting needs, and resolving conflicts.

In order to identify a comprehensive range of resource allocation options, it is vitally important to ensure that all affected and interested parties, as well as experts from relevant disciplines, have an opportunity to contribute. A systematic search for these persons should be initiated at the outset, and consultations held with as many persons as possible, on an informal basis initially (in order to explore a wide range of possibilities), and then later on a more formal basis (in order to obtain and accurately record specific suggestions). Records should be kept of conversations and meetings in case clarification is subsequently needed or disputes arise concerning sources of information or ideas.

A general difficulty is that certain key parties may be too busy to participate in the process of generating and selecting alternative proposals for formal evaluation. In addition, some parties with special vested interests may be reluctant to disclose information, or may distort information, in order to mislead or confuse others. Reliability checks and corroborating testimony will serve to partially alleviate these difficulties. In some cases, special investigations of disputed issues may be warranted. Scoping can reduce the level of conflict and disagreement that surrounds controversial projects by bringing concerned parties together as early as possible in the assessment stage. With a sensitive, neutral facilitator guiding the scoping process, new perspectives can be gained and parties can often reach consensus on the facts pertaining to many of the significant issues. Sometimes there may even be unanimous agreement on a proposal which incorporates mitigating measures that satisfy major objectors.

A more detailed discussion of the two phases of this task is presented in what follows.

Generating Alternatives for Consideration

The first phase of this task is to generate viable alternatives. There is no universally acceptable procedure for formulating alternatives. Ideally the general approach would be to identify all potential land-uses within the study area and then design feasible resource allocation proposals for each land-use, but research resources are normally limited and it is necessary to adopt some procedure for identifying the most promising land-uses and plans.

The most reasonable approach might be to start with the proposals which are most acceptable to the land owner or responsible authority, and then conduct preliminary investigations to determine the potential impacts of these proposals. Then suggestions can be made as to how these proposals (or preliminary plans) can be modified to mitigate adverse impacts and enhance beneficial impacts, and so develop variations of the preliminary proposals that might be more acceptable to all concerned parties. Through consultations with the owner or authority, other affected parties, and a multidisciplinary group of experts, a number of preliminary proposals and variations to the preliminary proposals can be identified and investigated. This iterative process is intended to suggest possibilities for compromise and accommodation, and improve the general acceptability of the proposals.

In order to promote cooperation and greater understanding, all interested parties should be given ample opportunity to comment on preliminary proposals or variations of these proposals. Feedback on proposal acceptability is important to the process of generating alternatives and should be formalized (for example, committees could be formed to discuss competing proposals). Plan proposers should liaise and interact with critics in a way which will enhance information transfer and reduce potential conflict. Proposers can then obtain specific objections to a proposal (so that they can anticipate problems and devise solutions that will pre-empt these), as well as useful suggestions as to how to improve the proposal (so that it will be more acceptable to other parties). Considerable time and effort should be devoted to the exchange of ideas and information in a congenial and stimulating atmosphere - this will improve the prospects of formulating a list of alternative proposals which are few in number and high in quality, and may even result in selection of a proposal which is acceptable to all parties, thus obviating the need for a formal evaluation.

In addition to proposals put forward by the various interested parties, there are three basic proposals which should always be considered:

- the "status quo alternative" (maintaining the present or existing situation);
- the "without positive action alternative" (the most likely situation to develop if no positive action is taken); and
- the "restoration alternative" (returning the area to a more near-natural state).

Several group techniques can be used to generate alternative proposals: formal or informal committees, discussion groups, brainstorming, and Delphi and Nominal Group Technique (Burton, undated).

Selecting Alternatives for Evaluation

Once the major alternatives are clearly defined, a few (preferably two or three) are selected as final proposals (the most promising variation of each preliminary proposal) to be subjected to a detailed evaluation. This is to be accomplished in consultation with affected parties and appropriate authorities, using formal or informal techniques for assessing the viability and desirability of the various major alternatives. The objective of this phase is to devise a compromise proposal if possible, or to at least reduce the number of alternative proposals to more manageable proportions in order to permit a formal evaluation to be accomplished at a reasonable cost.

It is possible (though not likely) that all affected parties will agree that one proposal is clearly superior to the others and should be adopted. If a compromise proposal is found, then it is obviously not necessary to continue with the Panel Evaluation Method but only to conduct more informal evaluations in accordance with the general Integrated Environmental Management procedure (see Appendix H). Even when there is a lack of such agreement, several of the variations of preliminary proposals might be eliminated by general consensus.

All surviving variations of each preliminary proposal - henceforth called "final proposals", or simply proposals - should be drafted by the project coordinator in consultation with the advocates of that proposal, and then presented to opponents of the proposal. This is to ensure that all avenues of compromise are fully explored, enhance the prospects of finding a mutually acceptable compromise proposal, and identify those proposals which can be dropped from further consideration because they will obviously prove to be too unrealistic or unacceptable.

In the case of especially important resource allocation decisions, it may be desirable to initiate special studies to investigate the economic, environmental, or social implications of certain alternatives. Special evaluation and decision making techniques, such as Overlays, the Sondheim Method, Decision Analysis, and Cost-benefit Analysis can be applied as required to assess these implications (see Appendix A, Appendix D, and Cost-benefit Analysis in Chapter 3). The actual methods and techniques employed, and the breadth and depth of the evaluation or analysis, will depend on the significance of the proposal (to the proposer and to society at large), technical considerations and the resources available.

When all these consultations and investigations have been completed, each proposer will select one variation of his proposal to be considered for formal evaluation. Proposers might sometimes be persuaded to withdraw proposals which are unlikely to rank high in terms of the three evaluation criteria, and to negotiate with other proposers to modify their proposals to obtain their support. If there are more than two or three final proposals, it may be necessary to conduct further investigations or discussions, or use other procedures, to reduce the number of proposals that will be subjected to a detailed evaluation to a more manageable number. In especially important but difficult or contentious cases, final proposals can be selected through a series of feasibility studies of increasing complexity and expense.

Although the process of generating and selecting alternatives for evaluation can be complex and time-consuming, in practice it is usually not difficult to identify the most promising variations of the preliminary proposals, and often the final proposals will soon emerge after a few investigations and limited discussion. Nevertheless, this task should not be treated lightly - many researchers simply accept proposals as given, and fail to consider whether there might be more promising alternatives, with the result that inferior resource allocation proposals are often evaluated and presented to decision makers for final approval, or investigations and evaluations prove to be largely irrelevant to the decision making process.[9]

9. This proved to be the case, for example, in the study that was done of the Groenrivier area, described earlier (see Case Study 1 in Chapter 4).

The Rietvlei Case Study: The Alternative Proposals

In 1971, Milnerton Estates engaged a firm of consulting engineers to assess the feasibility of creating a marina development at Rietvlei. The general proposal was found technically feasible, and so a consortium of consultants was appointed to design specific proposals which could then be evaluated in terms of financial viability. This consortium designed five basic schemes; some of these schemes had more than one variation, so that there were a total of 12 schemes to be considered. Due to a variety of circumstances, no action was taken on these plans, but when the Cape Provincial Department of Nature and Environmental Conservation announced their desire to proclaim Rietvlei a nature area under the Environment Conservation Act 100 of 1980, the managing director of Milnerton Estates made a statement that the area constituted a valuable asset and indicated that a marina scheme was still desired and would be pursued when market conditions were favourable.

The project coordinator held a series of meetings in late 1982 with several individuals to discuss the current viability of the original marina schemes and to identify possible alternative developments. The Milnerton City Engineer pointed out that two of the marina schemes could be redesigned to be generally compatible with the nature area project; he also suggested several totally new alternatives, such as a recreational harbour at the golf course or Flamingo Vlei, a resort development east of Flamingo Vlei, and a high density residential development on dunes adjacent to the vlei-lagoon. One of the original consulting engineers also had several suggestions, such as a proposal to put a small-craft harbour at the mouth of the lagoon which could link up to extensions to Cape Town's harbour. This proposal would be a compromise since the lagoon would be developed but the vlei could be left as a nature area.

These various proposals were discussed with the managing director of Milnerton Estates, and although some of them appeared to be of interest, he eventually decided, for a variety of reasons, to not accept any of the new suggestions and to submit only one of the original 12 proposals for evaluation: scheme "A5". The description of this scheme is contained in the briefing document presented in Appendix CC.

As regards the nature area project, a series of meetings were held in September and October 1982 with four members of the Rietvlei Nature Area Management Subcommittee (which had been formed in early 1981 to recommend how the area should be managed if proclaimed) in order to develop one or more management plans for evaluation. Several variations of a basic plan were discussed, and eventually a preferred plan was selected which met all the management policy guidelines which the subcommittee had previously adopted. The description of this plan is also contained in the briefing document in Appendix CC.

Discussions with the two proponents and other interested parties as to the desirability of investigating any other basic proposals were not productive, and it appeared that the area has little potential for any other use. The "status quo alternative" was not considered desirable since grazing produced little return for Milnerton Estates and the tax burden was high. The "without positive action alternative" was considered even less desirable since dumping, littering, and alien infestation - already a problem - could be expected to increase. The "restoration alternative" closely corresponded to the nature area project, and it was not considered necessary to treat this as a separate alternative.

Although new (fundamentally different) alternatives and possible variations to the preliminary alternatives were discussed with the proposers of the competing plans, neither of the principal parties - Milnerton Estates and the Rietvlei Nature Area Management Subcommittee - were particularly interested in a compromise *solution. The Directors of Milnerton Estates preferred scheme A5 to any other proposed use of the area, and members of the Management Subcommittee were not prepared to accept anything less than the whole vlei-lagoon system for a nature area.*

Task 4: Select Members of a Panel to Evaluate the Final Proposals

Assuming no compromise solution is found, and two (or possibly three) mutually-exclusive proposals are selected for evaluation, the next step is to form a panel of respected persons to participate in the evaluation process. Because it is vitally important that the judgments of the panel are respected by all concerned (and especially the decision makers), the principal consideration in choosing panel members is that their participation will be acceptable to all affected parties. Decision makers and representatives of the affected parties should therefore be given an opportunity to reject (without any questions asked) anyone they find unacceptable, and the selection of panelists should be done by some procedure which minimizes the possibility of bias.

The panel has three principal tasks:

- to identify and define, with the assistance of special "*advisors*" - experts and concerned parties - the impacts which could result from implementing each of the final proposals;
- to judge the relative social significance of these impacts; and
- to recommend which proposal is superior in terms of the three criteria for evaluating a proposal's overall contribution toward improving social well-being.

The major function of the panel is to make value judgments concerning how society will be affected by the alternative proposals. While there is no generally agreed-upon way to express or measure the "correctness" of value judgments, many judgments - such as the degree to which social well-being would be affected by an impact - can be expressed in numerical terms, and a group's average opinion is more likely to be acceptable than that of any given individual.

Assuming there is a "correct" answer to a value question, the accuracy, reliability and acceptability of a group judgment will depend in part on the size of the panel. The number of panelists should be great enough to ensure that a broad range of viewpoints, arising from a diversity of information and value systems, are represented on the panel. Dalkey *et al.* (1972:17) found in experiments with group judgments concerning factual data that average group error decreases and reliability of group responses improves with increasing group size. (In these tests conducted by Dalkey, the largest group was 29.) This would indicate that for group value judgments there could be some critical number of participants below which such judgments would be suspect. Hogarth (1978) investigated the question of how many experts were needed to achieve an "optimum" prediction, and concluded that 8 to 12 is enough; beyond this, Hogarth suggests that the criterion for adding members is whether more expertise is thought to be needed to increase group validity. Rohrbaugh (1979:90), in a study involving 141 panelists in 26 groups, found that heterogeneous groups with greater potential ability tended to make better decisions, and that the size of the group did not account for any significant additional variation.

Dalkey *et al.* (1972:17-19) tested a number of variables which could affect the "accuracy" of a group judgment. Among other things, Dalkey suggests that the accuracy of group judgment can be assessed by evaluating the dispersion of the group judgment. In addition, the reliability of group judgment can be assessed by evaluating the correlation between judgments made by two or more panels of similar size and composition.

These methods were used in the course of research done for this dissertation to assess group judgments concerning the relative significance of impacts[10]. It was found that panels as small as 8 to 11 members produced results with a degree of dispersion that might be regarded as

10 Dalkey also used a method of self-rating to test for accuracy, but self-rating was felt to be irrelevant in matters concerning the expression of subjective value judgments.

acceptable; in addition, the results produced by different panels were reasonably well-correlated with one other (see Assessment of the Significance Measurement Technique in this chapter, and Case Studies 4 and 5 in Chapter 6). Nevertheless, since better results were obtained with slightly larger panels, while no significant improvement was obtained with very large panels, it is recommended that an evaluation panel should consist of approximately 15 persons.

The evaluation panel should be multidisciplinary in nature to ensure that different points of view and types of expertise are represented, but individual panelists need not be experts in any particular field. It is obviously desirable, however, to select panelists who are likely to have special knowledge or insights pertaining to the issue at hand which they can impart to fellow panelists on site visits, and as part of the feedback (through anonymous comments) during the Delphi evaluation. In order to ensure acceptability, it is important that prospective panelists are widely regarded as being impartial, of unimpeachable integrity, and capable of exercising superior judgment. The panelists must be persons whose judgments are likely to be respected by all concerned parties, not just because they have special expertise or standing in the community, but because they are regarded as being holistic thinkers, and because they are perceived as being concerned and knowledgeable about the human condition.

The nomination and selection of panelists is obviously a critical process. The "*chain-referral technique*" provides a means of identifying prospective panelists who are respected members of the community, and final panel selection can be done in a manner which minimizes the influence of personal bias and ensures that a broad spectrum of viewpoints will be obtained.

The first step in the chain-referral technique is to prepare a list (preferably with the aid of proponents of proposals and responsible authorities) consisting of community leaders, academics, businessmen, government officials, professionals from relevant disciplines, and other individuals who are in responsible positions or are well known to the community. The project coordinator then sends a letter to each person on this list, briefly describing the nature of the study and the type of person required for the panel, and then asking that individual to recommend persons who would be eminently qualified to sit on such a panel. Letters are subsequently sent to persons who have been so recommended, asking them, in turn, to recommend candidates for the panel. This process is continued until a substantial list of prospective panelists has been compiled. This list is then submitted to representatives of the affected parties for approval, and any person who is considered unacceptable by any party is struck from the list.

The project coordinator then reviews the "approved list" and selects the individuals he considers would constitute a balanced, reliable, and respected panel. This is a major responsibility, and the project coordinator needs to guard against bias in determining the final composition of the panel. One approach to avoiding possible bias is to have each potential panelist indicate his primary field of specialization and the type of institution with which he is associated, and then randomly draw representatives from each field. Figure 5.3 presents a matrix which could be developed for this purpose. The acceptability of this prospective panel (and proposed alternates) should be cleared once more with the decision makers, since it is vitally important that the panel be regarded as balanced and the individual panelists are regarded with some esteem; if the decision makers do not sufficiently respect the judgment of the panel (particularly as to the relative significance of the impacts associated with each proposal) then the credibility of the entire evaluation procedure will suffer.

After clearing the final candidates for the panel with the decision makers, the project coordinator should contact each prospective panelist to fully explain the study and invite him or her to participate. It is advisable to arrange for the participation of more persons than are required, since it may be anticipated that several will be unable to attend meetings or complete the evaluation process.

PRIMARY FIELD ON SPECIALISATION	INSTITUTION							
	STATE DEPTS & STATUTORY BODIES	PROVINCIAL GOVT	LOCAL GOVT	QUASI-STATE	ACADEMIC (Universities)	COMMERCIAL ENTERPRISES	PRIVATE PRESSURE GROUPS	TOTAL
Construction Engineering								
Catchment Management								
Freshwater Research								
Freshwater Supply								
Power Research								
Habitat Preservation								
Habitat, Recreation Utilisation								
Habitat Research								
Agricultural Research								
Agric Production								
Environmental Planning (Biophysical)								
Environmental Planning (Socio-economic)								
Public - Political Decision-makers								
Legal								
Commerce								
Cultural/Historical								
Education								
Surveyors, Architects, Town Planners								
TOTAL								

FIGURE 5.3 **Matrix to Guide Selection of Panel Members**

The Rietvlei Case Study: The Panel

A list of prospective Delphi panelists was compiled by the project coordinator, in consultation with several colleagues, and a letter was sent to each person on the list explaining the nature of the study and asking if he or she would be prepared to serve on the evaluation panel. In addition, the reply form which was enclosed (with a self-addressed, stamped envelope provided) asked the prospective panelist to list the names (and addresses, if known) of any other persons who might possess the qualities specified and should be considered for inclusion on the panel. (The wording of the letter indicated that due to funding constraints no fee would be paid to the panelists, and this was confirmed in subsequent telephone conservations with selected panelists.)

Identical letters and reply forms were sent to persons nominated, and this process was repeated until a substantial list of cooperative individuals was obtained. The list of prospective panelists was then presented to the Deputy-Director of the Environmental Conservation Branch of the Department of Environment Affairs, the Managing Director of Milnerton Estates, and the Chairman of the Rietvlei Nature Area Management Subcommittee, who were all asked to indicate which of these persons might not be considered acceptable as panelists. Those who were not regarded as suitable by any one of these key people were struck from the list.

The project coordinator then selected the panelists from those who had been approved by the decision makers and the principal contending parties. Special consideration was given to constituting a well-balanced panel (representative of a variety of disciplines and backgrounds) that would be regarded as objective and fair. Those persons who were nominated but had not been selected, either because they were not acceptable to the principal parties or because the project coordinator thought they might be considered to have vested interests or be regarded as biased in respect to either of the proposed projects, were put on a separate list of persons who would be asked to serve as "advisors" in the impact identification and definition process. Thirty persons were selected as panelists, and 29 persons as advisors.

Task 5: Identify and Define the Impacts Which Could Result From Each Final Proposal

Before the impacts of the final proposals can be formally evaluated, they must be systematically identified and clearly defined. Panel members are to be given principal responsibility for identifying and defining all potential impacts associated with each proposal. While other persons should also play a role in this crucial task, it is important that the persons who will be judging the ultimate significance of these impacts are intimately involved in the identification and definition of the impacts.

Panelists are therefore to be assisted in this task by "advisors" selected by the project coordinator. Advisors are persons who might be affected by any impacts, as well as persons who have some special knowledge or expertise relevant to the study. Unlike the panelists, these persons are not chosen for their holistic and unbiased perspective but for their specific knowledge, and they may be biased in respect of the proposals. In fact, representatives of the various interested parties are to be specifically invited to participate in this task to ensure that all impacts of any concern to anyone will be identified and defined.

Considerable time and effort should be spent in identifying and defining all the potentially affected groups and the impacts that could be of concern to them because of the critical importance of this task. Many environmental evaluation methodologies are not sufficiently concerned with this step, with the result that some potential impacts are not investigated at all, while others are not addressed properly. A rigorous, iterative procedure is needed to ensure that all potential impacts (of possible concern to anyone) are identified, and then formally and thoroughly defined so that all parties will interpret them in the same way.

Environmental analysts often fail to ensure that a fully comprehensive and clearly defined list of potential impacts is prepared early in the Environmental Impact Assessment process, and this common failing results in ubiquitous complaints that important community concerns (or the interests of certain groups in the community) were misinterpreted and not properly addressed in the environmental report, or that some impacts were given inordinate weight in the evaluation stage because of double counting. Studies with such shortcomings can confuse and mislead evaluators and decision makers, and alienate members of the public who feel their concerns were neither clearly articulated nor adequately considered. One of the principal strengths of the Panel Evaluation Method is that great care is taken to obtain a complete and clear explication of potential impacts using the Impact Identification Technique.

The major objectives of the Impact Identification Technique are to ensure that:

- the list of impacts is fully comprehensive, so that all potential impacts of any concern to anyone will be included in the evaluation;
- the impacts are clearly defined, so that there is complete agreement as to exactly what is meant by each impact definition during the evaluation;
- the impacts are truly discrete or independent, so that there is no double-counting in the evaluation; and
- the impacts are arranged in a hierarchical structure, so that the relationship of those impacts which are part of and subordinate to more generally defined and more relevant impacts will be clearly delineated, and so that there will be fewer impacts to be separately evaluated.

A general description of the Impact Identification Technique is presented in what follows.

Description of the Impact Identification Technique

Those persons (panelists and advisors) selected to formally participate in the impact definition process will receive a briefing document, prepared by the project coordinator, which describes the study, the study area, and the final proposals (see Appendix CC for an example). This document may also furnish a set of notes to assist in the identification of potential impacts. In addition, a set of impact identification forms, for listing both the adverse and the beneficial impacts of each proposal, is to be included with the document.

After reviewing this briefing document, panel members (as well as any experts which have been engaged) should normally be taken on a conducted site visit to gain familiarity with the area and to be given an opportunity to ask questions before completing the impact identification forms. (It should generally not be necessary to take potentially affected parties who are assisting with impact identification on a site visit, since they will probably be sufficiently familiar with the area to identify potential impacts, and in any case will not be involved in the evaluation process.) In addition to a visit to the study area, it is desirable to take panelists to other areas which have developments similar to those being proposed for the study area to acquaint panelists with the kinds of impacts that could conceivably arise. Panelists should be accompanied on this site visit by a proponent of each proposal, as well as persons with relevant expertise, to further explain the proposals and answer any questions, and to ensure that all sides of the issues are presented.

Panelists should be encouraged to take notes, and after the site visit each panelist is to describe, on the appropriate forms, the kinds of impacts (both adverse and beneficial) which might occur from each proposal. These brief descriptions of potential impacts are then submitted, through the post, to the project coordinator.

When a number of impact identification forms have been received from the panelists and others, the project coordinator begins to compile the first draft of an amalgamated list of potential impacts (*i.e.*, a synthesis of all the impacts identified by the participants), which is then sent to panelists and other participants for comments. Impact definitions are subsequently modified in light of the comments, and new impacts may be listed. Then the revised list of potential impacts is returned to the participants for further comment. This process can be repeated until there is general consensus as to the identify and definition of the impacts.

In producing the amalgamated list of impacts, the project coordinator is guided by the following considerations.

The Need to Define End Impacts

All impacts should be phrased to indicate, to the extent possible, their ultimate effect on people. What is important is the "*end impact*", *i.e.*, how impacts ultimately affect social well-being (Abelson, 1976:244), and therefore impacts to the biophysical environment should be regarded as "*intermediate impacts*" and re-phrased to clearly indicate their implications for social well-being. For example, an impact that is initially phrased as -

"Habitat destruction will reduce populations of migratory waterfowl"

- suggests that the loss of waterfowl should be of some concern to society, but does not specify what these concerns might be, or reveal the nature of the ultimate impact(s). The statement simply indicates that there will be certain physical impacts (to unspecified elements of waterfowl habitat), that will in turn lead to biological impacts (to unspecified species of waterfowl); but there is also an implication that these biophysical impacts will eventually result in social impacts (to, *e.g.*, aesthetic, recreational, economic and scientific interests). Therefore, in addition to the obvious need to eventually clarify and examine the specific biophysical impacts that could result, there is a less obvious but more fundamentally important need to identify and consider the final or end impacts on social well-being.

The Need to Define Independent Impacts

In order to avoid general confusion and double-counting, particular care must be taken to ensure that the final impact statements are discrete or "independent": the primary or end impacts must not significantly overlap (*i.e.*, imply the same thing) or interact with others (*i.e.*, produce a noticeably greater effect when taken together than they do when considered separately). Impact statements which are very similar to others, and impacts which may be regarded as a sub-category of another impact, are therefore to be aggregated and stated in more general form. Those impacts which do interact or overlap should then be listed as subimpacts which can be regarded as descriptive statements that serve to explain the nature of the more general impact definition. Impacts are thus to be presented in a hierarchical structure, with overlapping and interacting socioeconomic impacts (as well as intermediate biophysical impacts) listed as subimpacts which are subordinate to truly independent, end impacts. To carry the example presented above further, a re-examination of the elements of concern which gave rise to the initial impact description -

"Habitat destruction will reduce populations of migratory waterfowl"

- may reveal that there are three end impacts (to society) implied by this general intermediate impact (to a biological resource):

- diminished variety and beauty in the present landscape;
- potential loss of genetic information; and
- reduced attractions for recreation and tourism.

In order to clarify the issues, avoid double-counting of impacts, and shorten the list of items to be evaluated, these concerns relating to migratory waterfowl might be better grouped with other concerns relating to maintaining diversity and aesthetic quality in the landscape, avoiding genetic losses, and protecting resources needed for outdoor recreation and tourism. Thus a hierarchical presentation, with intermediate impacts (and more specific impact descriptions) subsumed under the relevant end impacts (and more general impact descriptions and headings), will facilitate the orderly and logical arrangement of impacts without losing any information or specificity (see Box 5.3 for an example).

BOX 5.3
Example of Hierarchical Presentation of Impacts

UNPRICED COSTS OF THE MARINA PROJECT

REDUCED LANDSCAPE DIVERSITY AND AESTHETIC QUALITY

The variety and beauty of the present landscape would be diminished by the loss of open space, natural features, and biological elements, all of which act as a "green lung" for the urban environment:
a) .....
b) .....
c) .....
d) the destruction of biological habitat and sources of primary production would reduce the numbers and therefore the pleasing visual and auditory impacts of some populations, particularly highly-valued species of water birds;
e) .....
f) .....

INCREASED RISK OF LOSING BIOLOGICAL RESOURCES

Potentially valuable genetic information could be lost if habitat destruction reduces gene pools beyond safe levels:
a) .....
b) another link in the system of wetlands used by migratory species of water birds will be eliminated, and this could endanger the viability of some populations;
c) .....

LOST RECREATION AND TOURISM BENEFITS

Opportunities for several outdoor recreational pursuits will be diminished, and the area's appeal to tourists may be impaired:
a) reducing the area available for golf, hiking, bird watching, horse riding, trail bike riding, flying model aircraft, etc. would deprive metropolitan Cape Town's large and rapidly growing population of recreational opportunities - this could increase sociological pressures, decrease the efficiency of the local work force, and lower the overall quality of life for urban residents;
b) .....
c) .....

<u>The Possibility of Reducing the Number of Impact Lists</u>

If desired, it is possible to reduce the number of lists to be evaluated in order to simplify the evaluation procedure. When two proposals are mutually exclusive, all impacts for each of the two proposals can be stated in terms of "costs" only (*i.e.*, direct adverse effects or foregone opportunities to obtain some benefit provided by an alternative proposal), <u>or</u> "benefits" only (*i.e.*, direct positive effects or opportunities to avoid some cost associated with an alternative proposal). For example, the beneficial impacts of Proposal A can be regarded as foregone opportunities associated with implementing Proposal B. Therefore, in order to simplify the evaluation procedure to be conducted later, all impacts can be phrased in terms of costs: a beneficial impact of Proposal A, "Fifty jobs will be created", can be listed as an adverse impact, "An opportunity to create fifty jobs will be lost", for Proposal B. The result is a list of costs only for each proposal. (It is also possible, of course, to list all impacts as benefits instead of costs - *e.g.*, the adverse impact of one proposal, "Twenty jobs will be lost", can be listed as a beneficial impact, "Twenty jobs will be saved", of the alternative proposal).

When all participants (and particularly the panelists) are satisfied that every potential impact associated with each proposal under consideration has been identified and properly defined, the final list of potential impacts will be used to direct specific investigations into potential environmental impacts. This list will also be used to guide the Significance Measurement Technique (see Task 7).

<u>The Rietvlei Case Study: The Identification of Impacts</u>

Once panelists and advisors had been selected, the briefing document (see Appendix CC) and impact identification forms were sent to both groups. Arrangements were made to take the panelists (but not the advisors) on a half-day site visit accompanied by a proponent of each of the two proposals, as well as an estuarine ecologist and an environmental economist. (It was assumed that the advisor group would have sufficient familiarity with the area, or be motivated to obtain enough information, to fill in the impact identification forms, without a special site visit.) It was necessary to divide the large panel into four smaller groups for the site visit, and these groups were taken to the site on separate days. Time constraints did not allow visits to existing marinas and nature areas in the Cape Peninsula, but the panelists demonstrated general familiarity with such areas in their questions and discussions.

After receiving the completed impact identification forms from both the panelists and the advisors, the project coordinator produced a synthesis of the potential impacts which had been identified. The benefits listed for each project were reformulated and expressed as costs (or foregone opportunities) of the other project, so that there was a list of costs only for each proposal. Then this document, which both listed and defined the impacts, was sent back to the participants (both panelists and advisors) with a covering letter explaining how and why impacts were grouped and sometimes rephrased, and requesting comments for further improving or clarifying impact definition (see Appendix DD).

The potential impacts on each of the two lists were arranged in a hierarchical structure so that overlapping and interacting impacts for each proposal were treated as subimpacts and subsumed under more encompassing terms or definition statements, but still presented in order to elucidate the nature of the principal or discrete impacts.

After reviewing comments on the list of potential impacts, the project coordinator revised the lists of impacts to address concerns that had been expressed and, under a covering letter requesting further comment, distributed the new list of potential impacts to participants (see Appendix EE). Since no further comments or suggestions were subsequently received, this second version of the impact lists was accepted as reflecting the general view of the panelists and advisors, and the document was then used to direct further investigations into the nature, magnitude, and possible significance of nonmonetary impacts which could possibly result from the implementation of the two proposals.

Task 6: Investigate and Prepare a Report on the Potential Environmental Impacts Associated with Each Proposal.

After the impacts have been identified and defined to the panel's general satisfaction, the project coordinator will normally engage experts from appropriate disciplines to investigate and report on the nature of each impact. The extent of the investigations will depend on the importance of the issues and the availability of resources. The primary objective of these investigations is to convey an impression of how social well-being will be affected by the impact. If possible, the investigation should present estimates (and associated probabilities) of the possible magnitude of the impacts, but informed opinion is also sought on

- the timing and duration of each impact,
- the social groups that would be differently affected and how they would be affected,
- associated risks and secondary effects, and
- possible measures for mitigating adverse impacts and enhancing beneficial impacts.

Normally there will be both monetary and nonmonetary impacts. If the monetary costs and benefits of each proposal can be estimated with reasonable accuracy, then the present discounted value of each proposal can be calculated to provide a starting point for a comparative evaluation.[11] If deemed practicable, the project coordinator may also employ shadow-pricing techniques to estimate the monetary value of certain external costs or benefits, and thereby reduce the area of uncertainty in a comparative evaluation.

If the present discounted value of each proposal can be estimated, it will then be possible to calculate the excess monetary value of one proposal over the other (see A Proposal for Resolving the Measurement Problem in Chapter 4). This value can either be listed as an impact itself, the significance of which can be weighed directly against nonmonetary impacts, or it can be used to calculate a contingency price for any of the nonmonetary impacts, using the fractional contingency price valuation procedure. In this latter case, if a reliable shadow price can be obtained (at reasonable cost) for just one impact, comparisons of the relative efficiency of the proposals can be greatly facilitated.[12] In either case, if this monetary value is to be meaningfully related to the nonmonetizable outcomes of the proposals, it is necessary to obtain sufficient information about the nonmonetary impacts to permit the panel to make reasonable judgments as to the relative significance of these impacts.

When the reports of the expert consultants have been received, the project coordinator compiles an "*impact report*" which summarizes and consolidates the material in these reports. This impact report should be reviewed by the expert consultants and others with special knowledge that might be relevant to the issues addressed. This is necessary to guard against bias and interpretive errors, and ensure accuracy and completeness. After review, the impact report is then sent to panel members to assist them in evaluating the social significance of the impacts in the Delphi meeting.

Panelists should have an opportunity to obtain clarification on any aspect of the report, and to propose new impact definitions, before the evaluation procedure begins; it is important that the project coordinator ensures that all panelists are still agreed that the list of impacts for each proposal is complete, and that impacts have been satisfactorily defined and explained.

The impact report prepared by the project coordinator should follow a prescribed format to ensure that all topics that could influence significance determinations will be specifically addressed for each impact. The following format is recommended.

- General nature of the impacts
- Possible magnitude of the impacts (and probability of occurrence)
- Potential effects on social groups differently affected
- Timing, duration, and reversibility of the impacts

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11 It should be noted that from the point of view of persons living today, it is appropriate to discount the present value of any costs and benefits occurring in the future; the point of view of generations to come cannot be properly considered in efficiency and equity analysis, and is best treated separately through an explicit analysis of intergenerational or "sustainability" effects. See Appendix F for further discussion of the discounting issue.

12 For example, assume the excess monetary value of Proposal A over Proposal B is R10m; assume also that the relative significance of Impact X of Proposal A has been determined to be 20% of the value of all nonmonetizable impacts, so that a contingency price of R2m can be calculated for Impact X; assume further that a shadow price of R3m has been obtained for Impact X; then since the nonmonetizable costs of Proposal A exceed its excess monetary value, Proposal B is more efficient.

- Special risks and secondary effects associated with the impacts
- Measures to mitigate adverse impacts and enhance beneficial impacts.

The panelists are to be instructed to carefully review the contents of this report before beginning the evaluation procedure. The report should be concise and focused on the salient issues. Miller (1985) points out that although confidence increases with the amount of information available, the actual quality of decisions starts to decrease after a modest level of information is reached. Information overload can lead to simplifications which bias judgment.

The Rietvlei Case Study: Investigation of the Impacts

Due to the limited resources available to this study, and the fact that during the course of the study it was announced in the media that the South African Cabinet had in principle taken a decision to declare Rietvlei-Milnerton Lagoon a nature area, it was not considered practical to thoroughly investigate the impacts which had been identified, or to prepare an impact report, and so panelists were simply assembled to conduct an evaluation based on their existing knowledge of the situation, and using the briefing document and hierarchically-structured impact lists in the list of potential impacts.[13]

Although an impact report was not completed, Appendix FF presents the general approach that was being followed. Among other things, this appendix illustrates the recommended format for an impact report, which could then easily be incorporated into the final environmental evaluation report (see Task 9).

Task 7: Judge the Relative Significance of Each Proposal's Impacts

After the impact report has been studied by the panelists, the panel is convened for a Delphi meeting (an alternative procedure is to use questionnaires sent through the post).[14] The first object of the meeting is to apply the Significance Measurement Technique (see Impact Evaluation in this chapter) to judge the relative significance of the impacts.[15] This will make it possible to determine which proposal is more efficient.

Most of the work done during the Delphi meeting is directed at accomplishing this task - evaluating the relative significance of impacts listed for each of the proposals - in order to achieve an acceptable level of reliability (and presumably validity) in this very difficult assignment. The Significance Measurement Technique provides a means of merging the evaluations of different individuals into a single group perspective. A major advantage of the technique is the speed and ease with which it can be applied: two proposals can be evaluated by a panel of approximately 15 persons in a single half-day session. If there are more than two proposals, and there are more than about ten impacts for each proposal, then it may be desirable to arrange other meetings in order to avoid panel fatigue. Since the Significance Measurement Technique appears to be highly reliable (see Case Study 4, Assessment of the Evaluation, in Chapter 6), it might even be acceptable to use different panels to evaluate different pairs of proposals.

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13 This, of course, is not the most desirable approach to environmental evaluation, and several of the panelists felt that they did not have sufficient information to judge the relative social significance of certain potential impacts. Nevertheless, the great majority of the panelists agreed that even with this disadvantage, the evaluation procedure clarified one's thinking and was a useful exercise. This would indicate that if resources are not available to conduct a thorough environmental impact assessment, it is still worthwhile to formally identify, define, and evaluate the impacts using the Impact Identification Technique and Significance Measurement Technique.

14 Postal evaluations also appear to produce reliable results (see Case Study 4, Assessment of the Evaluation, in Chapter 6) but evaluations can be accomplished much more quickly if panelists are brought together in a meeting.

15 The second object of the meeting - to recommend which proposal best satisfies the three evaluation criteria - will be discussed in the next section.

Following is a description of the major steps involved in applying the Significance Measurement Technique.

Description of the Significance Measurement Technique

The impacts of each proposal, which have previously been arranged on separate lists, are now given to the panelists for evaluation. It is desirable to have two lists of impacts for the panel to evaluate so that while evaluations for one list are being processed for feedback to the panel, the panel can meanwhile be engaged in evaluating the other list. This alternation of lists helps to retain the panel's interest and makes better use of the panel's time. If one proposal is being evaluated against the null option (*i.e.*, doing nothing) then the panel can alternate between a list of costs and a list of benefits for that proposal. If two proposals are being evaluated, impacts for each proposal can be presented in one of two ways:

- costs and benefits are listed separately, so that there are two lists for each proposal; or
- all impacts are expressed as either costs or benefits, so that there is only one list of impacts for each proposal.

During the course of the meeting, panelists are asked to independently rate, rank and finally weight the impacts on each list. In order to facilitate the ratio-scoring procedure, which is the heart of this task, considerable effort is first placed on achieving, for each panelist, a rank-ordering of the impacts of each proposal in which the panelist has considerable confidence (see Impact Evaluation in this chapter). Since it is difficult to rank-order a long list of impacts, a rating procedure is used to facilitate this ranking. After going through several iterations of rating the impacts for each proposal, each panelist will use his final rating scores to achieve a rank-ordering of impacts. The panelist should then be sufficiently familiar with the process of comparing the relative significance of the impacts to be comfortable with undertaking the ratio-scoring procedure.

After a general introduction to explain the Delphi procedure and what is to be accomplished during the meeting, each panelist privately and anonymously rates, on a scale of 1 to 7, the impacts that have been identified for each proposal. Pre-printed, colour-coded forms are used for this purpose. If a desk-top computer is available, group scores are tabulated with the aid of a microcomputer programme, and the results fed back to the panel in the form of computer-generated histograms and group means (Ellis, 1982).

After receiving the feedback, panelists are asked to compare their personal rating scores with those of the group as a whole and consider reasons for any differences in evaluation. If any of the panelists desire to convey some information which might serve to enlighten other members of the panel as to the possible importance of any impact, comments of a factual nature may be anonymously written and submitted to the project coordinator. These comments will be passed on to the panel with histograms and other feedback from the second iteration.[16] Panelists are then asked to re-rate the impacts.

Group rating scores for the second iteration are calculated and returned to the panel as before, along with any comments which were submitted in response to the results of the first iteration. After this feedback, panelists are again asked to compare their scores with those of the group, and consider any comments which have been provided, and then undertake a third rating. Written comments are again solicited.

This process can be continued until there is no further convergence toward consensus or new comments offered, but normally three iterations will be sufficient (see Case Study 4, Assessment of the Evaluation, in Chapter 6). After the last set of histograms and comments are displayed or distributed, panelists are asked to rate the impacts a final time, and to use this final

16 Histograms and comments may be copied onto transparencies and displayed with the use of an overhead projector, or photocopies may be distributed to the panelists; it is also possible for the project coordinator to read aloud the anonymous comments to the group.

rating to rank the impacts in order of importance. Each panelist thus arrives at his own personal ranking of impacts, so that the impacts are arranged in order of importance according to his best judgment; this personal ranking will then be used by the panelist to judge the relative importance of the impacts.

The first step in the ratio-scoring procedure is for each panelist to choose the "threshold impact", the lowest-ranked impact that passes the "threshold of significance" (see Impact Evaluation in this chapter). The importance or "value" of this impact is then compared with the value of each of the impacts ranked above it. Those impacts which the panelist judges would be totally inconsequential to present-day society will be disregarded in the subsequent weighting procedure, while this first impact to pass the threshold of significance will serve as a benchmark to systematically evaluate how much more important every other impact is when compared to the one which has been selected. By combining the judgments of the panelists, the procedure results in a measure of the relative significance of each impact as judged by the group as a whole.

The Rietvlei Case Study: The Relative Significance of Each Proposal's Impacts

On 30 and 31 March 1983, Delphi meetings were held at the University of Cape Town to judge the relative significance of the nonmonetary impacts associated with each project. A total of twenty-eight individuals had accepted invitations to participate, but several people were unable to attend, so that one panel consisted of 8 persons and the other of 11 persons. This affected the composition of the panels in terms of professional affiliation and disciplinary orientation, since one panel now had a higher proportion of academics and biologists than the other. One might therefore expect judgments made by the two panels to be less well correlated than would have been the case if the panels had been more balanced.

The Delphi meetings were held in a comfortable conference room, and a data processing unit was set up nearby, equipped with a microcomputer and printer, typewriter, and photocopy machine. The project coordinator and an assistant stayed in the conference room throughout the meeting, and three persons were stationed in the data processing room. Two messengers were assigned to the conference room to transfer data to and from the data processing room. Rating and weighting scores were entered into the computer, and comments were typed separately in order to reduce processing time. Computer printouts and typed comments were then photostated so that each panelist received his own copy of the feedback. Processing time for each iteration ranged from 10 to 15 minutes, and while judgments for one proposal were being processed, work continued on the other proposal, so that no delays were experienced.

Panelists were first asked to rate *the importance of each of the 10 impacts associated with the marina project, using the form illustrated in Figure 5.4), in order to help the panelists later* rank *and then* weight *these impacts. The rating procedure was accomplished four times, with feedback of group ratings in the form of histograms three times (see Figure 5.5). Written comments were solicited after the second and third iterations (see Figure 5.6), and these were also fed back to the panel. After each iteration, panelists recorded their ratings on a Personal Summary Sheet (see Figure 5.7) in order to more easily compare their ratings with those of the group as a whole. This Personal Summary Sheet was also used to record a fourth and final rating after feedback from the third iteration. This last rating was not handed in for processing, but used by each panelist to facilitate his personal ranking of the impacts on an Impact Weighting Form (see Figure 5.8), and this ranking was used to weight the impacts using the ratio-scoring technique (see Impact Evaluation in this chapter).*

While waiting for the results from each of the three iterations of rating the marina project impacts, the panel was employed in rating and weighting impacts

MARINA PROJECT

IMPACT RATING FORM

PARTICIPANT'S NUMBER: 12 ITERATION NUMBER: 3 DATE: 30-3-83

IMPACT LETTER	VERY UNIMPORTANT			MODERATELY IMPORTANT		EXTREMELY IMPORTANT		IMPACT LETTER
	1	2	3	4	5	6	7	
A		2						A
B			3					B
C							7	C
D					5			D
E						6		E
F		2						F
G	1							G
H		2						H
I	1							I
J	1							J
	1	2	3	4	5	6	7	

FIGURE 5.4 **Example of a Completed Impact Rating Form**

```
VOTING FOR X
LOST RECREATION AND TOURISM BENEFITS

          7 : *
          6 : **
          5 : ***
IMPACT    4 : **
          3 : **
          2 :
          1 : *

          7 : *
          6 : *
          5 : ******
IMPACT    4 : **
          3 :
          2 :
          1 : *

          7 :
          6 : **
          5 : ********
IMPACT    4 :
          3 :
          2 : *
          1 :
```

FIGURE 5.5 **Example of Three Iterations of Rating Feedback**

MARINA PROJECT

COMMENT SHEET

PARTICIPANT'S NUMBER: 12 DATE: 30-3-83

IMPACT: G Flood absorbtion will be much better with wide flood control opening to the sea.

IMPACT D: Group should remember that there are very few reasonably unspoilt wetlands left in this important biological / geographical region.

FIGURE 5.6 **Example of a Completed Comment Sheet**

MARINA PROJECT

PERSONAL SUMMARY SHEET

PARTICIPANT'S NUMBER: 12 DATE: 30-3-83

IMPACT LETTER	RATING (1st.)	RATING (2nd.)	RATING (3rd.)	RATING (4th.)
A	3	2	2	1
B	2	2	3	3
C	7	7	7	7
D	5	5	5	5
E	5	6	6	5
F	3	3	2	2
G	1	1	1	1
H	1	2	2	1
I	2	2	1	1
J	3	1	1	1

FIGURE 5.7 Example of a Completed Personal Summary Sheet

MARINA PROJECT

IMPACT WEIGHTING FORM

PARTICIPANT'S NUMBER: 12 DATE: 30-3-83

RANKING	IMPACT LETTER	WEIGHTING
1	C	160
2	E	85
3	D	80
4	B	20
5	F	10
6	H	X
7	A	X
8	I	X
9	G	X
10	J	X

FIGURE 5.8 **Example of a Completed Impact Weighting Form**

NATURE AREA PROJECT

IMPACT RATING AND WEIGHTING FORM

PARTICIPANT'S NUMBER: 12

DATE: 30-3-83

IMPACT LETTER	VERY UNIMPORTANT		MODERATELY IMPORTANT			EXTREMELY IMPORTANT		RANKING	IMPACT LETTER	WEIGHTING
	1	2	3	4	5	6	7			
A				4				1	F	150
B	1							2	G	30
C					5			3	C	15
D			3					4	A	10
E	1							5	D	10
F							7	6	E	X
G					5			7	B	X

FIGURE 5.9 **Example of Combined Impact Rating and Weighting Form**

associated with the nature area project. A different procedure was used for the nature area project, however, in order to test panel reaction to the value of multiple iterations of rating and to compare two different approaches to weighting impacts. For the nature area proposal, only a single iteration of rating was accomplished, and after feedback the impacts were weighted using a combined rating/weighting form (see Figure 5.9). The panel subsequently weighted the impacts a second time using the constant-sum method, in which 1 000 points were distributed over all the impacts (see Methods of Scaling Data in Chapter 3).[17]

Results of the ratio-scoring weighting procedure for both proposals and for the combined meetings are presented in Table 5.2. It was decided to use weightings from the combined meetings in the report to the decision makers and concerned parties. The aggregation of results from the two meetings may be considered reasonable if one accepts the hypothesis on which the Significance Measurement Technique is based (see Impact Evaluation in this chapter); although this hypothesis was not confidently confirmed in this case study, the material and procedures used in both meetings were identical, and the results were highly correlated (see Assessment of the Significance Measurement Technique in this chapter), even though the panels were somewhat dissimilar and there was no impact report provided. It was therefore thought that the judgment of the combined panels would be acceptable, and possibly preferable to those of either panel on its own.

TABLE 5.2
Results of Ratio-Scoring (Combined Panels)

MARINA PROJECT		NATURE AREA PROJECT	
A	15,95	A	17,27
B	17,38	B	4,69
C	19,56	C	8,77
D	14,54	D	10,02
E	8,24	E	28,92
F	10,48	F	24,87
G	4,01	G	5,47
H	2,28		
I	5,45		
J	2,11		
	100,00		100,00

Task 8: Identify the Proposal Which Best Meets the Selection Criteria (Efficiency, Equity, Sustainability)

The second objective of the meeting is to make a systematic comparison of the alternatives in terms of the three evaluation criteria. This is done by applying the Criteria Trade-off Technique, which involves asking each panelist to complete a form which leads him through a specified procedure for applying and trading-off the criteria. The procedure consists of two steps: first ranking the proposals according to each criterion, and then selecting the proposal which is superior considering all three criteria together.

17 The panel's reaction to conducting a single iteration of rating was negative: the consensus was that the multiple iterations of rating done for the marina project were helpful in preparing for the ratio-scoring, whereas the second iteration of weighting for the nature area project did not seem to improve individual or group evaluations.

After each panelist has completed the ratio-scoring procedure, he will have a better feel for the relative efficiency of the competing proposals. In addition, his study of the impact report should have given him a good understanding of how the respective proposals will affect different social groups, and some idea of the implications for future generations.

If one proposal is judged superior in terms of all three criteria, then it is obviously the preferred proposal. But in most cases, no single proposal will excel in terms of all three criteria. It is then necessary to apply some acceptable procedure for selecting the proposal which seems, in the judgment of most panelists, to have the best overall potential for advancing social well-being.

Following is a general description of the Criteria Trade-off Technique.

Description of the Criteria Trade-off Technique

The recommended procedure is to ask the panel to systematically compare the effects of the proposals using an evaluation format which emphasizes the criteria in a specific order: efficiency, equity, and sustainability. The efficiency criterion is to be applied first because if a proposal is to have a positive net social value, it is generally necessary that benefits exceed costs; an inefficient proposal will usually not be given serious consideration. Also, decision makers generally seek to advance social well-being by making efficiency improvements: only after identifying the more efficient proposals will decision makers normally consider the distributive consequences of the proposals; those which significantly violate the equity criterion may then be rejected.[18]

After applying the equity criterion, some consideration is then given to the effects of the proposals on the well-being of future generations, and if any appear to have unacceptable consequences for future generations, these may also be rejected. This criterion is applied last because there is often considerable doubt as to the effects an action will have on future generations (because of unpredictable changes in tastes and preferences, income levels, technology, and other factors), and because decision makers are primarily concerned with improving the well-being of their immediate constituency (*i.e.*, persons constituting the present population).

If only two proposals are being evaluated, a simple procedure can be used for applying and trading-off the criteria. Each panelist is asked to write out a personal evaluation statement using a form (see Box 5.1) which guides him through the criteria evaluation and trade-off process. If more than two proposals are being evaluated, another evaluation form (to be used in conjunction with the personal evaluation statement) can be employed to ensure that criteria are applied and traded off in the proper order.[19] After systematically comparing each pair of proposals in order to rank the proposals by each criterion, the panelist then selects the preferred proposal by a process of elimination (see Box 5.2 for an illustration of the final evaluation procedure that can be employed in this case, after the proposals have been ranked in terms of the various criteria).

The project coordinator should use his discretion to decide whether the criteria evaluation should be done at the end of the Delphi meeting or on another occasion. If panelists are obviously tired at the end of the impact weighting session, they may do a more thorough job on the personal evaluation statements if more time and reflection can be devoted to them on another occasion. If the project coordinator feels that the panelists will be willing to undertake the Criteria Trade-off Technique at another time, he may ask panelists to complete the forms at home and return them through the post. In other cases it may even be desirable to ask the panelists to employ the Delphi method (either in another meeting or through the post) in order to seek consensus as to which proposal best meets the evaluation criteria.

18 It should be noted that market solutions can sometimes be found, or redistributive measures taken, to rectify the inequitable distribution of costs and benefits for an efficient proposal; this is usually the preferred course of action, and is another reason why the efficiency criterion is applied first.

19 A different ordering than that presented in Figure 5.2 is of course possible, and Appendix F presents a case for applying the sustainability criterion first and the efficiency criterion last.

In any case, when the personal evaluation statements are completed, the judgments of the panelists are to be assembled by the project coordinator and included in the final environmental evaluation report.

The Rietvlei Case Study: Identifying the Proposal Which Best Meets the Selection Criteria

In order to complete the evaluation procedure, eight panelists who agreed to attend another meeting (and who were not necessarily representative of the original panels) were asked to complete a personal evaluation statement. The nature area project was judged by this panel to excel in terms of all three criteria on the first iteration, although one panelist felt that the marina project was more efficient, and one other panelist felt that the marina project was more equitable. The following remarks, paraphrasing comments from the personal evaluation statements, are presented to illustrate the type of reasoning applied to the problem by the panelists.

Efficiency Effects: "It seems reasonable to assume that at least 100,000 people will visit the nature area every year, and if they just use R2,00 worth of petrol per person, that would indicate a willingness to pay of R200,000.[20] In fact, people spend far more than this to visit other natural areas around the Cape, and over the next 50 years there will be more people willing to pay even more to visit such areas."

Equity Effects: "Converting the area into a marina would benefit only a few people - mainly the new residents who would live there - and these people are well-off and have the mobility to visit natural areas outside the city. The poor, and particularly the non-white sector, would then have reduced opportunities to enjoy healthy outdoor recreational activities. Also, the loss to conservationists would be much greater than the gain to prospective marina users, and there is no way to compensate conservationists for this loss. People who want to live in a marina scheme can go to Marina da Gama."

Intergenerational Effects: "Future generations will live in a crowded and overdeveloped world so will probably value visits to natural areas far more than we do. We should be prepared to set aside special areas, such as the only vlei-lagoon system in the region and its rich bird-life, for the pleasure of those who will follow us. What we would be giving up is very little in comparison with what they would gain."

In this case, the task of applying the evaluation criteria was relatively straightforward and did not present any difficult trade-offs. Even the panelists who did not rate the nature area superior in terms of all three criteria were confident that the nature area was superior overall.

Task 9: Analyze the Results and Prepare an Environmental Evaluation Report

After the Delphi evaluation process is completed, the project coordinator analyzes the results and documents the findings in an environmental evaluation report. This report, though intended primarily for the decision makers and proponents of the mutually-exclusive alternatives, should also be made available to any concerned party on request. This is so the evaluation will be seen as open and above board.

The report should be quick and easy to compile since it will consist largely of material already prepared for other purposes. Much of the material needed for the environmental

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20 The reasoning here was based on a contingency price of R2,111,000 that was calculated for Impact F of the Marina proposal, "Lost Recreation and Tourism Benefits"; the question that is posed is whether the community would be willing to pay this amount over 50 years to maintain these benefits. Using a discount rate of 10%, and assuming benefits are the same every year, then the annual willingness to pay for these benefits would have to be R212,926.

evaluation report will be contained in the briefing document, the list of potential impacts, and the impact report.

The heart of the report will, of course, be an analysis of the results of the efficiency evaluation and the application of the evaluation criteria accomplished by the Delphi panel. This part of the report can take different forms, depending on the approach that has been taken to the study.

For the efficiency evaluation, each pair of proposals are to be compared to determine which proposal would yield the highest net benefit to present members of society. Normally there will be both monetary and nonmonetary costs and/or benefits associated with each proposal. Cost-benefit Analysis and shadow-pricing techniques can be applied to collapse as many impacts as possible into a single monetary value, so as to reduce the number of nonmonetizable impacts to be considered.

If only one proposal is left with adverse impacts which are completely nonmonetizable, then the monetary value of this proposal can be used to calculate fractional contingency prices for its nonmonetary impacts, using the basic fractional contingency price valuation procedure[21] (see A Proposal for Resolving the Measurement Problem in Chapter 4). But a more complex situation exists if both proposals have a number of significant unpriced costs. For these cases, a variation of the fractional contingency price valuation procedure has been developed, although it may be regarded by some as of academic interest only because of its relative complexity and potential for cumulative error.

This variation of the procedure involves comparing the relative significance of unpriced costs associated with each proposal in order to eliminate impacts of equivalent social value, so that one is left with a list of costs for one proposal only. Then it is possible to calculate a contingency price for any of the remaining nonmonetary costs of the proposal with the excess monetary value, and make a single trade-off as before (see Box 4.1). The following steps are involved:

- After the excess monetary value of Proposal A (the development proposal) over Proposal B (the conservation proposal) is calculated, the scores given to all unpriced costs for both proposals are aggregated and normalized (this can be done if it is assumed that the first cost which passes the "threshold of significance" for one proposal is comparable in significance to its counterpart for the other proposal).

- Then all of Proposal B's unpriced costs may be compensated for by eliminating unpriced costs of Proposal A which have equivalent scores.

- The scores for Proposal A's remaining unpriced costs are then summed, each score divided by the sum, and each result multiplied by 100.

- Contingency prices can be calculated for any of the remaining impacts by multiplying the excess monetary value of Proposal A by these new percentage scores.

There are other possible approaches to evaluating the efficiency of a proposal. For example, the monetary value of a proposal can simply be listed along with the nonmonetary impacts, and its relative significance evaluated in the same way as the nonmonetary impacts (using the ratio-scoring procedure). If the net monetary value of a proposal cannot be calculated with any degree of confidence, then the analyst can simply describe the general financial implications as clearly and accurately as possible, and list these along with the nonmonetary impacts.

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21 While it is possible to calculate contingency prices immediately after the ratio-scoring procedure, and then ask panelists to use these to judge whether a proposal meets the efficiency test, the use of contingency prices and other aspects of a full efficiency analysis (such as the use of shadow prices) can be complex and will normally require careful study after the meeting.

This suggests two general ways in which the Delphi evaluation of the relative significance of impacts can be used to make efficiency determinations:

- The first general approach is to use the "fractional contingency price valuation procedure". If the excess monetary value of one proposal over another has been determined, the project coordinator can calculate a fractional contingency price for one or more of the impacts. Members of the panel can then be asked (either at the end of the meeting, or later through the post) to vote as to whether the value of the contingency price(s) exceeds that of the impact(s). In addition, if a shadow price can be obtained for any one of the impacts, that value can be compared to the fractional contingency price that has been calculated for the impact. If the shadow price for an adverse impact exceeds the fractional contingency price, then the proposal may be judged inefficient. Finally, the analyst may also wish to apply dynamic opportunity cost valuation as part of the analysis, if it is thought that the value of nonmonetary costs may be expected to increase over time relative to monetizable benefits (see Dynamic Opportunity Cost Valuation in Chapter 3).

- The second general approach is to use what will be referred to as the "*comprehensive valuation procedure*", in which monetary impacts are weighted along with nonmonetary impacts, and then the values assigned to both types of impacts on each of two lists are aggregated and compared to obtain a direct measure of efficiency. Two variations of this approach have been developed. In the first instance, if a direct comparison of the efficiency of two competing proposals is wanted, all impacts for each proposal can be expressed as either benefits or costs. After these are weighted, the results can be aggregated and it can be seen which proposal has the greater benefit or cost (see Case Study 4, The Results, in Chapter 6). In the second instance, if a single proposal is being evaluated (*i.e.*, being compared to the null alternative), then its impacts are to be expressed in terms of costs and benefits. After these are weighted, the results can be aggregated to see whether there is a net benefit or cost (see Case Study 6, The Results, in Chapter 6).

If is, of course, important that the rationale and assumptions underpinning the approach taken to the efficiency analysis are clearly explained in the evaluation report.

After the efficiency analysis has been completed, the proposals must be analyzed in terms of the other two evaluation criteria and trade-offs made to identify the preferred alternative. In addition to presenting the panelists' judgments pertaining to these criteria, and the way they have made the trade-offs, the analyst can also present a reasoned analysis based on cost-benefit data obtained for specific groups, and/or expert forecasts on future conditions. Very often, the trade-offs will be quite straightforward, particularly if there are only two alternatives. But sometimes the trade-off analysis could be quite complex, such as when each of three competing proposals excels in terms of one of the criteria. In these cases the analysis should be accomplished in a systematic way, guided by a model for making trade-offs, such as that discussed in Box 5.2 and illustrated by Figure 5.2. Appendix GG presents an example of a questionnaire that can be used by the panelists (or the analyst or decision maker) to guide the trade-off process.

Just as the cost-benefit concept helps the analyst and decision maker judge whether an action is efficient or not, when it is applied to groups differently affected by the action the concept is useful in determining whether the action is equitable. If some groups bear inordinate costs and others receive gratuitous benefits, and there is no satisfactory mechanism to achieve an acceptable redistribution of costs and benefits, then the action may be rejected even though it is efficient. While this type of judgment is obviously highly subjective, a clear formulation of the nature and extent of the costs and benefits falling to each group will greatly aid in making and defending judgments on questions of equity.

The cost-benefit concept is less useful but still relevant in analyzing the long-term implications of an action. It is extremely difficult to forecast costs and benefits from the point of view of future generations, not only because of the uncertainties associated with residual and higher-order impacts, but because future tastes and preferences are unknown, and the technological circumstances and economic and environmental conditions in which future generations will find themselves will vary from time to time and are extremely difficult to predict (Beckerman, 1972, 1974; Seneca and Taussig, 1979). Nevertheless, if there is compelling evidence that benefits will exceed costs for this generation only, and significant costs will remain for future generations to bear long after benefits have been exhausted, then the action may be rejected even though it is both efficient and equitable. While it is virtually impossible to judge the social significance of costs and benefits in the remote future (or even judge whether particular effects will be regarded as costs or benefits), decision makers surely have a responsibility to consider the welfare of future generations (Daly, 1987; Herfindahl and Kneese, 1974; Kneese and Schulze, 1985; Mishan, 1981; Page, 1977).[22] Therefore, an evaluation of the potential significance of costs and benefits from the perspective of future generations must be explicitly conducted.

The Rietvlei Case Study: Analysis of Results and the Environmental Evaluation Report

Although an environmental evaluation report was not prepared for this case study (because a decision had been taken before the study was completed), the report would have been a straightforward account of the outcome of each of the tasks which were undertaken in the course of the study. Most of the necessary material could have been directly incorporated from the briefing document, list of potential impacts, and impact report (see Appendices CC to FF). The only new material needed would have been an analysis of the Delphi meeting results, and a statement presenting conclusions and recommendations.

In this case, the present discounted value of each project had been previously estimated, and the excess monetary value of the marina project had been calculated but this was not listed as one of the benefits of the marina project. After the Delphi meetings, the project coordinator used the results of the ratio-scoring procedure to calculate contingency prices for each of the marina project's nonmonetizable impacts.

Since both projects had unpriced costs, it was first necessary to reduce the unpriced costs of the marina project by an amount comparable to the aggregate value of the unpriced costs associated with the nature area project. It was assumed that the weights given to impacts for both projects could be considered comparable since the scores assigned to all impacts had been related to the same base: the "threshold of significance" (see Impact Evaluation in this chapter). Therefore, the scores of the combined panels for the impacts of both projects were aggregated and normalized, so that the relative significance of the two projects' unpriced costs could be calculated (see Table 5.3). It was thus determined that the combined scores of marina impacts A, E, and H were roughly equivalent to the combined scores of all the nature area's impacts (20,76 vs. 20,88), and therefore all the unpriced costs of the nature area project could be removed from further consideration by also eliminating unpriced costs A, E, and H of the marina project. This left seven unpriced costs of the marina project to weigh against the excess monetary value of the marina project.

Scores for the marina project's remaining unpriced costs were then summed, each score divided by the sum, and each result multiplied by 100. These normalized

22 In fact, one could argue that given the growing disparity between First and Third World development, the gross distributional inequities within many countries, and the potential seriousness of many regional and global environmental threats, the traditional ordering and weighting of criteria in project evaluation - efficiency effects, equity effects, and intergenerational effects (see Box 5.2 and Figure 5.2) - should be reversed in many situations (see Appendix F).

scores were then multiplied by the excess monetary value of the marina project (R15,265,000) to obtain contingency prices for each of the impacts (see Table 5.4).

TABLE 5.3
Comparison of Marina and Nature Area Impact Weightings
(Combined Panels)

Marina Impact Weightings		Nature Area Impact Weightings	
C	- 15,83	E	- 5,64
B	- 13,94	F	- 5,23
A	- 12,61	A	- 3,19
D	- 11,72	D	- 2,49
F	- 8,07	C	- 2,03
E	- 6,38	G	- 1,43
I	- 4,04	B	- 0,87
G	- 3,15		
H	- 1,77		
J	- 1,60		
TOTAL	79,11	TOTAL	20,88

Weight of all nature area impacts (20,88) equivalent to weight of marina impacts A, E and H (20,76)

TABLE 5.4
Calculation of Contingency Prices

MARINA IMPACT	ORIGINAL WEIGHTING	ADJUSTED NORMALIZED WEIGHTING	CONTINGENCY PRICE
C	15,83	27,13	4 141 427
B	13,94	23,89	3 646 837
D	11,72	20,09	3 066 763
F	8,07	13,83	2 111 166
I	4,04	6,92	1 056 346
G	3,15	5,40	824 316
J	1,60	2,74	418 264
TOTAL	58,35	100,00	15 265 119

The next step was to select one of these remaining nonmonetary costs for making the final efficiency determination. Impact F, "Lost Recreation and Tourism Benefits", was selected since this impact seemed relatively easy to imagine in monetary terms. This impact constitutes 13,8% of the excess impact value of the marina project over the nature area project, and so one can consider whether the community would be willing to pay approximately R2m over 50 years to maintain recreation and tourism benefits associated with the nature area. In order to further simplify the analysis, the annual value of the contingency price can be calculated for presentation to the panel or decision maker. In this case, if the net present discounted value of recreation and tourism benefits is R2,111,166 over 50 years at 10%, and benefits are the same every year, then the annual value of these benefits is R212,926.

If resources had been available, it would have been possible to obtain shadow prices for recreation and tourism benefits to assist the panel in evaluating this fractional contingency price for reasonableness. For example, a willingness to pay *survey of metropolitan residents might have revealed whether the nature area's recreational benefits are greater than R213,000 per annum. Investigations could also have been made into current outlays on recreational visits to similar areas, fees paid to aquatic and golf clubs in the area, and assessments of the area's attractiveness to tourists. In addition, projections of future willingness to pay for such benefits (assuming marina benefits would remain stable or decline relative to nature area benefits) could have been calculated for the next 50 years to determine what the initial year's recreational and tourism benefits would have to be to meet the contingency price requirement for the entire period (see Dynamic Opportunity Cost Valuation in Chapter 3).*

After the contingency price for recreational and tourism benefits had been calculated, the following question was prepared to aid panelists, concerned parties, and decision makers in determining whether the marina project would be more efficient than the nature area project:

> "In your judgment, which of the following two outcomes has greater potential for making today's society better off?"
>
> Outcome A - Today's society must forego recreation and tourism benefits of the nature area project but will gain benefits worth R2m.
>
> Outcome B - Today's society will retain recreation and tourism benefits of the nature area project but must forego benefits worth R2m.

Since it may still be quite difficult to conceptualize the value of R2m, the nature of the choice can be further clarified by framing the following question:

> "Would metropolitan residents and visitors from other areas be willing to pay at least R213,000 per year for 50 years to maintain recreation and tourism benefits associated with the nature area project?"

If the answer to this question is no, then the marina project is more efficient; if the answer is yes, then the nature area project is more efficient. (These questions were in fact put to the panel which accomplished the criteria evaluation described in Task 8 above.)

In addition to the efficiency evaluation, the environmental evaluation report would have presented the results of the criteria evaluation. Since the participants in this evaluation had been unanimous in supporting the nature area proposal over the marina proposal, the report would have recommended that Rietvlei-Milnerton Lagoon be proclaimed a nature area.

To sum up, the Delphi evaluation technique indicated that the nature area project would be more efficient than the marina project if all unpriced costs are taken into account. In addition, the nature area project was judged to be a more equitable use of this unique resource, and would also better serve the interests of future generations.

ASSESSMENT OF THE SIGNIFICANCE MEASUREMENT TECHNIQUE

Because the principal research objective of this study was to develop a theoretically sound and practical way to determine the relative significance of unpriced impacts, special attention was given to assessing the potential of the Significance Measurement Technique for improving group judgment.[23]

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23 Although the effectiveness of other techniques and procedures associated with the Panel Evaluation Method were not so rigorously assessed, participants in the study seemed generally satisfied with the approach, and no fundamental criticisms were received.

An analysis of the results of the two Delphi meetings in the Rietvlei study indicates that the Significance Measurement Technique was successful in improving group judgment as to the relative significance of impacts. Nevertheless, no firm conclusions could be drawn due to the fact that the panels differed in some important respects, and both panels were relatively small: 11 members for Panel X (March 30) and 8 for Panel Y (March 31). The following analysis is restricted to the evaluation of impacts associated with the marina proposal since neither panel applied the full technique to the nature area proposal.

Dalkey *et al.* (1972:57) suggest that three tests can be applied to judge whether an evaluation technique has improved group judgment:

- there should be some convergence with feedback (*i.e.*, the standard deviation should decrease over the iterations, indicating greater consensus);
- judgments should be normally distributed around a single peak (*i.e.*, there should be a unimodal rather than a bimodal distribution, indicating that there is a single group point of view) ; and
- the results should be replicable (*i.e.*, the judgments of any two similar groups should be highly correlated).

Dalkey *et al.* (1972:57, 81) applied these three criteria to Delphi panels making judgments concerning factual information that would not be common knowledge, and to other panels making value judgments, and found that these criteria were satisfied to about the same degree for both applications; this indicates that Delphi procedures are appropriate for generating and assessing value material.

The results of the two evaluations of marina impacts were also assessed by these criteria and it was found that

- there tended to be convergence of opinion over three iterations,
- the distribution of ratings for the impacts on the final iteration were generally unimodal rather than bimodal, and
- the weighting scores for the combined lists for each of the two panels were highly correlated.

Table 5.5 presents a summary of the means and standard deviations calculated for the first and third iterations of both meetings, which indicates the extent to which opinions converged over the three iterations. Figure 5.10 presents histograms of the impact ratings for the third iteration of each meeting, which indicates which impact ratings had normal distributions. Table 5.6 presents the weightings given to the impacts by each of the two panels, which indicates how well the weighting scores were correlated.

A: Reduced landscape diversity and aesthetic quality

PANEL:	X	Y
7	*****	.
6	**	****
5	*	****
4	***	.
3	.	.
2	.	.
1	.	.

B: Increased risk of losing biological resources

PANEL:	X	Y
7	***	***
6	***	*
5	****	****
4	*	.
3	.	.
2	.	.
1	.	.

C: Lost options

PANEL:	X	Y
7	****	*
6	***	*****
5	***	*
4	*	*
3	.	.
2	.	.
1	.	.

D: Lost legacy

PANEL:	X	Y
7	*	***
6	****	**
5	****	*
4	**	*
3	.	*
2	.	.
1	.	.

E: Lost educational and research facility

PANEL:	X	Y
7	.	.
6	****	*
5	******	***
4	.	***
3	.	*
2	*	.
1	.	.

F: Lost recreation and tourism benefits

PANEL:	X	Y
7	.	.
6	**	**
5	********	******
4	.	.
3	.	.
2	*	.
1	.	.

G: Increased flooding risks

PANEL:	X	Y
7	*	.
6	.	**
5	.	*
4	****	***
3	*	*
2	**	*
1	***	.

H: Increased pollution risks

PANEL:	X	Y
7	.	.
6	*	.
5	.	**
4	.	*
3	******	***
2	****	*
1	.	*

I: Increased congestion effects

PANEL:	X	Y
7	.	**
6	**	.
5	*	.
4	*****	***
3	*	**
2	**	.
1	.	*

J: Increased social tension

PANEL:	X	Y
7	.	.
6	*	*
5	.	.
4	******	****
3	*	.
2	***	**
1	.	*

FIGURE 5.10 **Distributions of Ratings for Third Iteration**

TABLE 5.5
Change in Standard Deviation between First and Third Iteration of Rating

		PANEL X 30 MARCH		PANEL Y 31 MARCH	
		ITERATION		ITERATION	
		1	3	1	3
	n	10	11	8	8
A	mean	5,2	5,8	5,4	5,5
	std dev	1,7	1,3	1,5	0,5
B	mean	5,3	5,7	5,4	5,9
	std dev	1,5	1,0	1,2	0,9
C	mean	5,5	5,9	5,5	5,8
	std dev	1,2	1,0	1,0	0,8
D	mean	5,1	5,4	4,8	5,6
	std dev	1,1	0,9	1,7	1,4
E	mean	4,9	5,1	4,1	4,5
	std dev	1,6	1,1	1,3	0,9
F	mean	4,6	4,9	5,4	5,3
	std dev	1,6	1,0	0,5	0,4
G	mean	3,7	3,0	4,4	4,3
	std dev	2,0	1,8	1,8	1,3
H	mean	2,9	2,9	3,8	3,3
	std dev	0,7	1,1	2,0	1,3
I	mean	3,7	4,0	3,8	4,1
	std dev	1,4	1,3	2,3	1,9
J	mean	3,5	3,5	3,4	3,4
	std dev	1,2	1,2	1,4	1,5

TABLE 5.6
Correlation of Adjusted Weighting Scores

Cost of Marina Project	Percent of Total Nonmonetary Cost of Project	
	First Panel	Second Panel
A	18,45	12,52
B	17,46	17,26
C	18,92	20,44
D	13,64	15,78
E	9,72	6,21
F	10,39	10,60
G	2,04	6,72
H	2,07	2,55
I	4,77	6,39
J	2,55	1,52
TOTAL	100,01	99,99

CORRELATION COEFFICIENT = 0,902

An examination of the standard deviations calculated for rating scores from both meetings (see Table 5.5) reveals that the panelists generally moved toward consensus in their evaluation of the importance of each impact. The standard deviation was lower for the third iteration than for the first iteration in the case of 8 of the 10 impacts for Panel X and in the case of 9 of the 10 impacts for Panel Y. In addition, the ratings of each panel in the third and final iteration (see Figure 5.10) reveal a normal distribution of responses for 7 of the 10 impacts.[24] Nevertheless, the standard deviations of several impacts for both panels were rather high (particularly in the first iteration), and a significant proportion (30%) of the final distributions could be considered bimodal. These results indicate that either insufficient information about the impacts was provided to the panelists (no impact report was prepared), or that the value systems of individual panelists varied considerably.

While there may be some question as to whether the first two tests were adequately satisfied, there is less ambiguity on the third test. The correlation coefficient for the weightings that were given the impacts by the two panels (see Table 5.6) is over 0.9.[25] This result indicates that the Significance Measurement Technique yields data on subjective value judgments which may be regarded as reliable - *i.e.*, the technique is capable of eliciting judgments as to the relative significance of a list of impacts which are reasonably replicable.

Another interesting question that was addressed in this case study was whether the judgments of a more homogeneous panel would be well-correlated with those of more heterogeneous panels. Since a more homogeneous panel might be expected to lack the diversity of information and value systems that would be found within a more heterogeneous panel, it was postulated that comparisons between two such panels would not be highly correlated. In a pretest of the Significance Measurement Technique, a panel comprised of 15 Masters students enrolled in a course of Environmental Studies followed essentially the same procedures (although they were not involved in the impact identification process), and the results of their evaluation were subsequently compared to the results of the other two panels.

24 A normal distribution was defined as a curve with a single peak which falls away on both sides with no upturns that are more than one unit above the lowest measure on each side.

25 Using a one-tailed test, this is a strong positive correlation, statistically significant at the 99% level.

The correlation coefficients derived for this student panel (Panel Z) were 0.68 with Panel X and 0.38 with Panel Y. Although other factors could have contributed to these results, the relatively poor correlations lend support to the notion that the degree of panel heterogeneity can have an important influence on the reliability (and perhaps the validity) of judgments concerning the relative significance of impacts.

The question as to whether the Significance Measurement Technique substantially improves group judgment, or can be regarded as a reliable evaluation procedure, has not been adequately answered by this case study. As mentioned previously, no impact report was provided to the panelists, and although every effort was made to ensure that panel size and composition would be adequate for both evaluations, several panelists were unable to attend either meeting, or had to switch dates, so that fewer panelists attended the second meeting (8 vs. 11), and the disciplinary orientation of the panels were dissimilar (*e.g.*, there were more biologists and academics on the first panel). The results of this case study were encouraging, however, and so it was decided to undertake a more extensive testing programme involving larger and more numerous panels.

Another matter of concern was the fact that, although the judgments made by the two panels as to the relative significance of the impacts are highly correlated, there is considerable disparity in some of the values given. For example, the significance weights that the two panels assigned to two of the impacts - Impact A and Impact G - differ by 6,93 and 3,78 percentage points respectively. This would result in the computation of fractional contingency prices that might be regarded as differing by a substantial amount. While many of the weightings were very similar, and some of the differences in weightings could be due to the fact that the panels were small and not well-balanced, the possibility of such discrepancies in valuation of specific impacts could discredit the fractional contingency valuation procedure.

It was therefore decided to use the "comprehensive valuation procedure" in future applications of the Significance Measurement Technique. This procedure involves including the general financial implications of a proposal - or, preferably, the present discounted value or excess monetary value of the proposal - as an impact to be weighted along with the nonmonetary impacts. As previously discussed (see The Relevance of Economic Thinking to Resource Allocation in Chapter 3), the ultimate object of comparative evaluation is to determine the relative significance of <u>all</u> outcomes associated with two or more proposals, and to judge their performance in terms of specified evaluation criteria; monetary measures need <u>not</u> play a major role in this process. In fact, in Third World countries such as South Africa, there are often inadequate resources to conduct a thorough Cost-benefit Analysis, or to apply shadow-pricing techniques which have a sufficient degree of sophistication to instil great confidence. More appropriate to this situation are measures which, though somewhat cruder, are at least systematic and emphasize the final trade-offs to be made.

DISCUSSION

This chapter has presented a Delphi-based method for conducting a formal evaluation of controversial resource allocation proposals. The principal aim of this method is to provide a reasonable way to organize, improve and articulate group judgments in applying three evaluation criteria: efficiency, equity and sustainability.

To this end, three techniques have been devised and then applied in a case study, and the results have been encouraging. These techniques - which are based on Delphi principles of anonymous debate, controlled feedback and final displays of group response - are the Impact Identification Technique, the Significance Measurement Technique, and the Criteria Trade-off Technique.

The objective of the <u>Impact Identification Technique</u> is to determine what impacts are of concern and should be evaluated. The technique involves generating a comprehensive list of clearly-defined, discrete "end impacts" through an iterative procedure (usually conducted by post). This iterative procedure is undertaken by an evaluation panel and a group of advisors after reviewing a briefing document and making a site visit. The judgments of the participants are synthesized and the aggregated list is returned to each individual for comment. Impacts which are similar, or appear to overlap or interact, are combined into more general impacts which are truly independent. Intermediate impacts are subsumed under the principal, or "end impacts", which indicate the ultimate effect on social well-being. The iterative process continues until all participants are satisfied with the list of impacts and subimpacts; this list is then used to guide environmental investigations and the evaluation process.

The objective of the Significance Measurement Technique is to determine the relative significance of each impact so that judgments can be made as to whether a proposal is efficient (or is more efficient than an alternative proposal). This technique also involves an iterative process (usually conducted in a meeting situation) which is undertaken by a panel of persons respected by all concerned parties. The technique consists of three iterations of rating impacts, followed by a rank-ordering of the impacts so that a ratio-scoring procedure can be applied to measure the impacts on an interval scale. The ratio-scoring procedure is based on a concept called the "threshold of significance", which assumes that the point at which each panelist would first ascribe significance to an impact is effectively a "zero" point which can be used as a benchmark for scaling impacts; it is also assumed that the first impact to cross this threshold is not far from the threshold in each case, so that the "threshold impact" for each panelist constitutes an acceptable common point of origin.

The objective of the Criteria Trade-off Technique is to determine which alternative proposal best satisfies the three evaluation criteria. This technique requires each panelist to rank-order the proposals according to each criterion, and then to systematically trade-off the criteria to determine which proposal best satisfies all three criteria. The panelists silently and independently apply each criterion to the proposals by completing a "personal evaluation statement". This statement consists of four short essays (usually one paragraph each) explaining the reasoning for the rank-ordering given for each criterion separately and then for all criteria taken together.

Of particular concern was the question as to whether the Significance Measurement Technique is capable of providing reliable results. In order to assess the effectiveness of this technique, testing was needed to demonstrate whether the technique in fact improves group judgment. Therefore a hypothesis was formulated for testing, and an important objective of the case study was to test this hypothesis. The results are encouraging: the two panels involved in Case Study 3 produced judgments as to the relative significance of impacts that were reasonably well-correlated, and other assessment criteria (*viz.*, consensus with feedback, and unimodal distribution of response) were substantially satisfied.

Although the scaling technique seems to provide reasonable measurements of the relative significance of impacts, there remains some doubt as to whether the procedure for analyzing these results - the fractional contingency price procedure - is conceptually satisfying, or sufficiently accurate to make efficiency determinations that can be confidentially defended. It is concluded that other analytical procedures should be considered and tested, and a general approach called the "comprehensive valuation procedure" has been presented.

To sum up, all nine tasks prescribed for undertaking a formal evaluation were addressed in Case Study 3 (though not all were fully completed) to assess the general efficacy of the method. The results indicate that the method constitutes a sound and practical approach to evaluating controversial resource allocation proposals. More particularly, the three principal techniques associated with the Panel Evaluation Method appear to satisfactorily resolve the major difficulties associated with the evaluation procedures which were applied to Case Studies 1 and 2 (see Chapter 4).

Nevertheless, it was deemed necessary to conduct further tests to determine, among other things, whether different panels will produce replicable results, and to identify the conditions that are sufficient for achieving this result. In addition, further applications were desired to demonstrate the general flexibility and applicability of the Panel Evaluation Method and its associated techniques. The next chapter presents the results of further testing and analysis of the Panel Evaluation Method in its application to three additional case studies.

CHAPTER 6
TESTING AND REFINING THE PANEL EVALUATION METHOD: THE EXPERIENCE OF THREE ADDITIONAL CASE STUDIES

OVERVIEW

This chapter presents the results of three additional case studies which serve to demonstrate the general applicability of the method, the flexibility of the procedures used, and the general efficacy and utility of the three principal techniques. One objective of this part of the research programme was to show how other techniques or approaches for evaluating resource allocation proposals can be used in conjunction with the Panel Evaluation Method.

Special attention is given to assessing the reliability of the Significance Measurement Technique. In addition, an attempt was made to identify any conditions which are necessary for achieving replicability in the scoring of impacts. To this end, several panels were constituted to evaluate identical lists of impacts, but due to a lack of resources it was not possible to design a research programme that could adequately test all of the possible variables of interest.

Among the conclusions drawn from Case Study 3 was that the fractional contingency price valuation procedure might be regarded as too complex and imprecise to be accepted by decision makers and concerned parties as accurately reflecting the merits of the choice between two proposals (see Assessment of the Significance Measurement Technique in Chapter 5). It was therefore decided to include monetizable outcomes as impacts to be weighted on lists of impacts in future studies, so that all outcomes or impacts would be scored and an efficiency determination could then be made directly. Two general approaches were devised for accomplishing this.

In Case Study 4, the approach taken is to express all impacts (including monetary considerations) for each of two competing alternatives as benefits only. This approach, in addition to providing a means of directly comparing the net benefits of two proposals, also reduces the number of lists to be evaluated. This can be done because each proposal offers two kinds of benefits:

- a "direct" benefit that is greater than a comparable benefit offered by a competing proposal, or which is of a type not even offered by the competing proposal; and
- an "indirect" benefit that avoids some adverse impact that would result from the competing proposal.

This makes it possible to produce, for each proposal, a single list of impacts for scoring (it is also possible to express all outcomes as costs only). Once these impacts have been scored, then it is only necessary to sum the scores to determine which proposal has the greater benefit. It is assumed that the threshold impacts for each proposal are approximately equivalent so that they effectively constitute a common point of origin.

Case Study 6 utilizes an alternative approach to calculating the value of all impacts (including monetary considerations) associated with a given proposal. This is to produce both a list of costs and a list of benefits for the proposal, and then to simply aggregate the group scores assigned to the impacts on these two lists to obtain a measure of the net benefit for that proposal. If the net benefit is positive, and only the null alternative is being considered, then the proposal meets the efficiency criterion. If another proposal is being considered, then its net benefit must be calculated (by adding the values assigned to its costs and benefits) for comparison. This approach also assumes that the threshold impact on one list is equivalent in value to that on another list (*i.e.*, the threshold impact on a list of costs has the same degree of significance as the threshold impact on a list of benefits), or that these values can be adjusted in some way so that they can be considered equivalent.

Case Study 5 addresses several other matters of concern. One is whether the Impact Identification Technique is replicable - *i.e.*, whether it is capable of generating a list of impacts that would be substantially the same as that produced by another panel. Another is the question as to whether a panel can produce a list of impacts that would be more complete and more clearly defined than one produced by an individual environmental analyst. The third matter of concern is the extent to which the project coordinator can influence the panel's judgments regarding the identification, definition and scoring of impacts.

CASE STUDY 4

Background

The principal research objective of this case study was to further assess the efficacy of the Panel Evaluation Method, and particularly the reliability of the Significance Measurement Technique, in evaluating controversial resource allocation proposals. This study concerned a major water storage scheme that was proposed for the Palmiet River Valley.

The Palmiet River, about 60 km from Cape Town, is the only remaining major conventional water resource for the Greater Cape Town area. After several years of investigating potential water storage schemes, the Directorate of Water Affairs planned development of the river in two phases. Work on the first phase, the Upper Palmiet, was begun in the late seventies. For the second phase, the Directorate had designed six basic alternative water supply projects affecting the Lower Palmiet Valley, as well as several variations of each alternative. All of these schemes would partly inundate the Kogelberg State Forest, which is not actually a "forest" but a fynbos reserve (the term "fynbos" refers to the vegetation of the Cape Floristic Kingdom, which is the most species-dense flora in the world).

Because the Kogelberg State Forest was widely regarded as the best preserved of the eight major fynbos reserves, conservationists maintained that the costs of any of the projects would outweigh the benefits, particularly from the point of view of future generations. The Directorate was therefore persuaded to consider a seventh alternative that would not affect the Palmiet Valley: desalination of sea water. In addition, the Minister of Environment Affairs appointed a special task force, the Palmiet River Environmental Committee, to investigate the potential impacts of these alternatives.

In September 1982 the Palmiet River Environmental Committee requested the School of Environmental Studies at the University of Cape Town to conduct a socioeconomic evaluation to determine the "value" of the Kogelberg State Forest. In subsequent discussions, the project coordinator suggested that the objective should not be to value the Kogelberg State Forest as a whole, but rather those parts which would be lost under each alternative. Eventually the objective was reformulated, and it was decided that the study should be designed to accomplish two things:

- to ascertain the relative value of all impacts that could result from each of the major alternatives under consideration, and
- to evaluate the alternatives in terms of three criteria: net benefit to society, distributional consequences, and implications for future generations.

Because of the complexity of the evaluation task, and in order to meet deadlines and stay within budget, the project coordinator suggested that the study be restricted to three alternatives, one of which should be the desalination of sea water to provide an option that would not affect the Kogelberg State Forest. The Committee agreed to this, and selected what it considered to be the two most promising alternatives for detailed evaluation; these will hereinafter be referred to as the "Dam" and the "Weir".

The Dam scheme would provide more water storage than the Weir, as well as an opportunity to generate hydroelectric power; the Weir scheme (which had been developed in response to the demands of conservationists) would minimize the volume of water to be stored in the Palmiet River Valley (and therefore avoid damage to several key parts of the reserve) by pumping water via a series of tunnels to other storage facilities outside the Kogelberg State Forest. The Desalination scheme would be located somewhere on the coast in an area not considered environmentally sensitive (possibly in the vicinity of the Koeberg Nuclear Power station, in order to take advantage of waste heat from the reactors).

The Study

The project coordinator selected the Panel Evaluation Method as the principal means of evaluating the alternatives, but other techniques were also used to provide information to support the evaluation. In particular, the Contingent Valuation Survey technique and an adaptation of the Krutilla technique were utilized to estimate the present and future willingness of water consumers to save all or part of the Palmiet Valley. The data obtained through these techniques are presented and discussed in Appendix L.

Two local panels were formed to independently conduct evaluations in Delphi meetings, and three national panels were formed to independently conduct evaluations through the post. The two local panels were involved in all aspects of the evaluation, while the national postal panels were involved only in applying the Significance Measurement Technique. The object of using several panels was to assess the replicability of judgments made by different groups in applying the Significance Measurement Technique; of particular interest was the question as to whether iterations done through the post would produce the same results as those done in meetings, and whether one approach could be judged more effective than the other.

The "chain-referral technique" was used to identify prospective panelists, and a matrix display of prospective panelists was used to aid in the selection of a balanced, multidisciplinary panel (see Figure 6.1). For logistical reasons, only the local panels were involved in the impact identification and definition process. Members of these two panels were provided with background information and then taken to the site, as well as to the Upper Palmiet (Phase 1) project. After these visits, the panelists were asked to independently identify the impacts associated with each of the three alternatives and post this information to the project coordinator.

The project coordinator then synthesized the impact definitions; this involved combining impact definitions that were essentially the same, re-phrasing where necessary to indicate the ultimate or "end impact", and organizing the impacts into a hierarchical structure. The format used was to list, for each impact, a banner heading, a precise definition, and a series of subimpacts which further clarified the nature of the impact. The resulting document was posted to members of the local panels for comment.

In order to simplify the evaluation process, it was decided, with the agreement of the Palmiet River Environmental Committee, to make only two sets of comparisons: the Dam would be compared both to the Weir and to the Desalination scheme; the Weir would not be compared to the Desalination scheme since both of these options had been proposed as alternatives to the Dam in order to conserve part or all of the Kogelberg State Forest.

Further, it was decided that since what was being evaluated was the relative effects of pairs of alternatives, it would be appropriate to state all consequences in terms of either costs or benefits and not both. For example, avoiding the costs of one project could be counted among the benefits of the other project; even if there is a type of adverse impact that both projects have in common, the magnitude of the impact will vary so that avoiding the greater cost of one project may be regarded as part of the benefits associated with adopting the other project. In order, therefore, to reduce the number of impact lists to be evaluated, all effects were reworded and

PRIMARY FIELD ON SPECIALISATION	INSTITUTION: STATE DEPTS & STATUTORY BODIES	PROVINCIAL GOVT	LOCAL GOVT	QUASI-STATE	ACADEMIC (Universities)	COMMERCIAL ENTERPRISES	PRIVATE PRESSURE GROUPS	TOTAL
Construction Engineering		E	Ht	l		wf		6
Catchment Management	d							1
Freshwater Research	Ls			b				3
Freshwater Supply	k							1
Power Research							g	1
Habitat Preservation		Zu					j	3
Habitat, Recreation Utilisation	M		O				Cx	4
Habitat Research	B				ya			3
Agricultural Research	i				m			2
Agric Production						P		1
Environmental Planning (Biophysical)	Q	c		S	W	T		5
Environmental Planning (Socio-economic)	V		Y	F	vp	I	U	7
Public - Political Decision-makers	K	D	zo					4
Legal						n		1
Commerce					A	X		2
Cultural/Historical					N			1
Education	g			R		h		3
Surveyors, Architects, Town Planners		J	e		G			3
TOTAL	11	6	7	4	10	8	5	51

FIGURE 6.1 **Completed Matrix to Guide Selection of Panel Members**

expressed as benefits or advantages of one alternative over another. (The reason why relative effects were expressed in terms of benefits rather than costs was to try to give environmental evaluation a more positive image.)

Four lists of impacts were compiled:

List One - benefits of the Dam in relation to the Weir

List Two - benefits of the Weir in relation to the Dam

List Three - benefits of the Dam in relation to Desalination

List Four - benefits of Desalination in relation to the Dam.

These lists were forwarded to the local panelists with the request that they add new benefits, redefine benefits, and indicate any benefits which may be considered to overlap or interact. Responses to this request were used to reformulate the impact lists for each alternative, and new lists were sent to the panelists to ensure that participants were satisfied that all benefits had been identified and clearly defined. Several more comments were obtained, and changes made, until agreement was obtained from all panelists that the lists were satisfactory (see Appendix HH).

The resulting impact lists were used to guide an environmental impact assessment that culminated in an impact report (Stauth and Lane, 1983). This impact report was then distributed to local and national panels for use in the evaluation procedure. Because of the relative complexity of the evaluation process (involving three alternatives and four lists of impacts), and to avoid undue repetition, all potential benefits of the three water supply projects were grouped under 18 categories of effects to facilitate discussion and comparison. For example, the section "Category 1: Effects on Reliability of Water Supply" presented information pertaining to three of the four lists: (a) benefits of the Dam in relation to the Weir ("Increases reliability of water supply"); (b) benefits of the Dam in relation to Desalination ("Increases reliability of water supply"); and (c) benefits of Desalination in relation to the Dam ("Hastens development of more secure water supplies"). The analysis presented for each category then followed a uniform format, and consisted of material pertaining to five topics:

- general nature of the effects;
- magnitude and probability of effects;
- potential effects on social groups differently affected;
- timing and duration of effects; and
- possible secondary effects.

The impact report consisted of a synopsis of fact and opinion available to the research team which could assist panelists in judging the relative significance of the benefits which had been identified. An excerpt from the report, to illustrate the kind of information that was provided, is presented in Appendix II.

The local panels met separately in November 1983, and followed the previously-described evaluation procedures (see Tasks 7 and 8 in Chapter 5). The first task was concerned with determining the relative significance of impacts. This involved, for each list of items under consideration, three ratings with feedback, followed by a final rating and a ranking, and then accomplishing a ratio-scoring procedure based on the "threshold of significance" concept (see Impact Evaluation in Chapter 5). The second task was to apply the evaluation criteria to judge which proposal would be in the overall best interests of society.

Since it was felt that a panel could not be expected to work effectively for more than a half day, and since it would not be possible to complete the rating, ranking and weighting of all four lists in that time, it was decided to undertake part of the evaluation by post. During the meetings, Panel A evaluated the two lists associated with the Dam and the Weir, and Panel B evaluated the two lists associated with the Dam and Desalination. Each panel subsequently performed the other set of evaluations through the post so that comparisons could be made between these different methods of conducting an evaluation, and so that comparisons could be made between these two panels and the three postal panels.

Before the postal panel evaluations could take place, the project coordinator had to go overseas and another researcher conducted the postal evaluations, compared all the results, and compiled the final report for the Palmiet River Environmental Committee (Butcher, 1986). Subsequently, after the project coordinator returned, there was an opportunity to conduct still more Delphi meetings to further assess the reliability of the ratio-scaling procedure. These meetings were concerned with evaluating only the Dam and the Weir (Desalination was dropped because of various constraints).

In November 1986 two panels were formed from a multidisciplinary group of professionals enrolled in a short course on Environmental Impact Assessment offered by the Environmental Evaluation Unit of the Department of Environmental and Geographical Science at the University of Cape Town. Both panels were taken on a site visit and given documentation that included the two lists of benefits and relevant excerpts from the original impact report (Stauth and Lane, 1983). One of the principal objectives was to determine whether these panels, which had not been involved in the impact identification and definition process but would accomplish the evaluations in a meeting situation (rather than by post), would produce scores similar to those of the original panels.

In November 1987 the same exercise was repeated with a different group of professionals enrolled in the same course, along with a third panel comprised of Masters students in Environmental Studies. This student panel was a more homogeneous group than the any of the other nine panels (all of which were comprised of working professionals with a greater diversity of experience and interests), and it was expected that there would be greater differences between the weightings of the student panel and those of each of the professional panels than there would be between the latter.

The Results

The two local panels jointly applied the Impact Identification Technique, and this resulted in a total of 41 comparative effects to be evaluated (see Appendix HH):

- List One - the Dam had 14 benefits when compared to the Weir;
- List Two - the Weir had 6 benefits when compared to the Dam;
- List Three - the Dam had 9 benefits when compared to Desalination; and
- List Four - Desalination had 12 benefits when compared to the Dam.

Once the impacts (benefits) had been defined, the two panels conducted a comparative evaluation of the benefits associated with two pairs of alternatives (Lists One and Two on the one hand, and List Three and Four on the other) using the Significance Measurement Technique. Subsequently, over a period of several years, an additional eight Delphi panels (including the student panel) conducted evaluations comparing the benefits of one or both pairs of alternatives; these panels did not apply the Impact Identification Technique, but used the same lists of benefits generated by the two local panels.

For ease of reference, an alphabetical symbol for each panel involved in the Palmiet case study is assigned below; each panel designator is followed by the number of members comprising the panel and the year the panel conducted its evaluation.

Panel A (Local Panel): 14 members; 1983.

Panel B (Local Panel): 13 members; 1983

Panel C (Postal Panel): 17 members; 1984

Panel D (Postal Panel): 19 members; 1984

Panel E (Postal Panel): 24 members; 1984

Panel F ("Short Course" Panel): 18 members; 1986

Panel G ("Short Course" Panel): 18 members; 1986

Panel H ("Short Course" Panel): 22 members; 1987

Panel I ("Short Course" Panel): 19 members; 1987

Panel J (Student Panel) : 7 members; 1987

Each of these panels accomplished the prescribed rating, ranking and weighting procedures comprising the Significance Measurement Technique (see Impact Evaluation in Chapter 5) to obtain a group judgment as to the relative significance or value of the listed benefits of one or both pairs of alternatives. Some of the panels also applied the Criteria Trade-off Technique and completed individual personal evaluation statements (see Application of Selection Criteria in Chapter 5) in which panelists were asked to explicitly apply the three evaluation criteria so that the alternative judged superiour in terms of all the criteria taken together could be systematically identified.

Because the principal object of the research was to test and refine the Significance Measurement Technique, emphasis was placed on satisfactorily completing the ratio-scoring procedure, and for a variety of reasons not all the panels were asked to complete the personal evaluation statements. For each panel, the relative importance of benefits associated with each pair of alternatives was measured in the following manner (Table 6.1 illustrates the results of steps 2 and 3 of the procedure as it was applied to the results produced by Panel F):

- The weighting scores given by the panelists to all benefits on both lists were combined and summed.

- Each score on both lists was then divided by the resulting sum to obtain a new percentage score. These scores were then averaged for each impact to obtain a panel score.

- The panel percentage scores were then separated back into the original two groups (lists of benefits) and summed to determine which alternative received the higher total score.

This procedure can be regarded as valid only if it is assumed that there is an acceptable subjective point of origin, common to all panelists on a given panel, from which all benefits on both lists were scaled. It was felt that the "threshold of significance" concept provides a reasonable psychological datum point that satisfies the problem of subjective origins (see Impact Evaluation in Chapter 5), and that an acceptable test of this concept is whether two panels using the same material and procedures can produce replicable results.

In November 1983 Panel A evaluated Lists One and Two in a Delphi meeting, and Panel B evaluated Lists Three and Four in a separate Delphi meeting. Subsequently, Panel A evaluated Lists Three and Four by post, and Panel B evaluated Lists One and Two by post. Panels C, D and E evaluated both pairs of alternatives by post, whereas the remaining panels (F, G, H, and I) only evaluated the choice between the Dam and the Weir and conducted these evaluations in a meeting situation.

TABLE 6.1
Illustration of Procedure for Determining Final Weighting Scores for Proposals

1. PANEL F: RAW DATA, COMBINED LIST

	DAM vs WEIR														WEIR vs DAM					
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	2A	2B	2C	2D	2E	2F
RESPONDENTS																				
1	30	30	40	30	10	40	10	0	0	30	50	15	0	0	0	20	100	0	15	10
2	40	60	30	30	0	20	20	0	0	45	10	10	20	35	0	40	50	10	45	20
3	0	100	70	60	0	30	12	10	16	20	102	15	14	72	10	35	50	30	55	33
4	80	85	130	70	10	50	65	20	40	90	120	30	22	110	10	60	110	25	70	30
5	25	45	50	22	0	30	20	15	12	40	70	60	0	10	0	30	150	10	100	15
6	0	20	60	55	0	30	10	0	15	20	25	12	0	0	0	30	100	10	80	15
7	0	30	80	70	15	65	20	0	0	60	25	40	10	0	30	60	100	10	50	25
8	0	50	75	80	14	17	11	15	13	30	70	12	16	10	0	15	60	0	30	10
9	10	20	20	15	0	15	0	10	10	15	25	10	0	10	0	20	30	0	20	10
10	0	30	32	34	13	18	16	0	14	20	45	10	0	12	10	20	80	15	65	22
11	0	15	30	20	10	50	20	30	10	40	50	15	10	10	0	20	100	10	40	80
12	10	25	40	30	16	14	18	17	15	20	80	11	13	12	0	15	60	0	30	10
13	18	26	40	30	10	35	15	25	16	43	45	20	22	12	15	50	70	10	55	40
14	10	60	80	60	25	40	50	15	60	70	100	15	25	40	10	20	60	40	100	0
15	24	28	36	26	20	32	16	11	13	25	33	19	10	17	11	16	26	10	20	14
16	0	30	40	60	0	20	0	10	0	30	60	20	0	0	20	20	100	0	100	15
17	0	80	50	20	0	15	40	10	10	30	60	0	0	45	0	40	200	10	80	20
18	15	100	350	150	45	0	90	20	40	25	300	35	10	30	0	60	500	10	300	30

2. NORMALISED DATA (PERCENT OF INDIVIDUAL TOTALS)

	DAM vs WEIR														WEIR vs DAM					
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	2A	2B	2C	2D	2E	2F
RESPONDENTS																				
1	7,0	7,0	9,3	7,0	2,3	9,3	2,3	0,0	0,0	7,0	11,6	3,5	0,0	0,0	0,0	4,7	23,3	0,0	3,5	2,3
2	8,2	12,4	6,2	6,2	0,0	4,1	4,1	0,0	0,0	9,3	2,1	2,1	4,1	7,2	0,0	8,2	10,3	2,1	9,3	4,1
3	0,0	13,6	9,5	8,2	0,0	4,1	1,6	1,4	2,2	2,7	13,9	2,0	1,9	9,8	1,4	4,8	6,8	4,1	7,5	4,5
4	6,5	6,9	10,6	5,7	0,8	4,1	5,3	1,6	3,3	7,3	9,8	2,4	1,8	9,0	0,8	4,9	9,0	2,0	5,7	2,4
5	3,6	6,4	7,1	3,1	0,0	4,3	2,8	2,1	1,7	5,7	9,9	8,5	0,0	1,4	0,0	4,3	21,3	1,4	14,2	2,1
6	0,0	4,1	12,4	11,4	0,0	6,2	2,1	0,0	3,1	4,1	5,2	2,5	0,0	0,0	0,0	6,2	20,7	2,1	16,6	3,1
7	0,0	4,3	11,6	10,1	2,2	9,4	2,9	0,0	0,0	8,7	3,6	5,8	1,4	0,0	4,3	8,7	14,5	1,4	7,2	3,6
8	0,0	9,5	14,2	15,2	2,7	3,2	2,1	2,8	2,5	5,7	13,3	2,3	3,0	1,9	0,0	2,8	11,4	0,0	5,7	1,9
9	4,2	8,3	8,3	6,3	0,0	6,3	0,0	4,2	4,2	6,3	10,4	4,2	0,0	4,2	0,0	8,3	12,5	0,0	8,3	4,2
10	0,0	6,6	7,0	7,5	2,9	3,9	3,5	0,0	3,1	4,4	9,9	2,2	0,0	2,6	2,2	4,4	17,5	3,3	14,3	4,8
11	0,0	2,7	5,4	3,6	1,8	8,9	3,6	5,4	1,8	7,1	8,9	2,7	1,8	1,8	0,0	3,6	17,9	1,8	7,1	14,3
12	2,3	5,7	9,2	6,9	3,7	3,2	4,1	3,9	3,4	4,6	18,3	2,5	3,0	2,8	0,0	3,4	13,8	0,0	6,9	2,3
13	3,0	4,4	6,7	5,0	1,7	5,9	2,5	4,2	2,7	7,2	7,5	3,4	3,7	2,0	2,5	8,4	11,7	1,7	9,2	6,7
14	1,1	6,8	9,1	6,8	2,8	4,5	5,7	1,7	6,8	8,0	11,4	1,7	2,8	4,5	1,1	2,3	6,8	4,5	11,4	0,0
15	5,9	6,9	8,8	6,4	4,9	7,9	3,9	2,7	3,2	6,1	8,1	4,7	2,5	4,2	2,7	3,9	6,4	2,5	4,9	3,4
16	0,0	5,7	7,6	11,4	0,0	3,8	0,0	1,9	0,0	5,7	11,4	3,8	0,0	0,0	3,8	3,8	19,0	0,0	19,0	2,9
17	0,0	11,3	7,0	2,8	0,0	2,1	5,6	1,4	1,4	4,2	8,5	0,0	0,0	6,3	0,0	5,6	28,2	1,4	11,3	2,8
18	0,7	4,7	16,6	7,1	2,1	0,0	4,3	0,9	1,9	1,2	14,2	1,7	0,5	1,4	0,0	2,8	23,7	0,5	14,2	1,4

3. AVERAGES FOR PANEL; SUBTOTALLED FOR (1) DAM and (2) WEIR

DAM vs WEIR														WEIR vs DAM					
1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	2A	2B	2C	2D	2E	2F
2,4	7,1	9,3	7,3	1,5	5,1	3,1	1,9	2,3	5,9	9,9	3,1	1,5	3,3	1,0	5,1	15,3	1,6	9,8	3,7
													64						36
													(1)						(2)

TABLE 6.2
Comparison of Final Weighting Scores
Calculated for Both Pairs of Proposals by Nine Different Panels

Panel	A	B	C	D	E	F	G	H	I
Dam	67	59	66	69	74	64	66	72	71
Weir	33	41	34	31	26	36	34	28	29
Dam	32	30	40	41	42				
Desalination	68	70	60	59	58				

All panels found that the value of benefits associated with the Dam were greater than those of the Weir, and all of the panels which evaluated the choice between Desalination and the Dam found that the benefits of Desalination were greater than those of the Dam. Table 6.2 presents the final scores given by each panel to each pair of alternatives under evaluation. It can be seen that the ratio of values in each comparison of total benefits is approximately the same for each panel. This indicates that the threshold of significance concept constitutes a common point of origin for each pair of lists for all panels.

TABLE 6.3
Results of Personal Evaluation Statements

PANEL		Efficiency	Equity	Sustainability	Overall
A:	DAM	5	2	0	3
	WEIR	5	3	11	11
	UNCERTAIN	4	9	3	0
F:	DAM	8	7	1	3
	WEIR	9	10	17	15
	UNCERTAIN	1	1	0	0
G:	DAM	8	3	1	3
	WEIR	3	4	14	12
	UNCERTAIN	7	11	3	3
I:	DAM	15	8	3	9
	WEIR	3	2	8	7
	UNCERTAIN	1	9	8	3
B:	DAM	4	7	2	3
	WEIR	9	0	11	10
	UNCERTAIN	0	6	0	0

As stated earlier, not all panels were able to complete personal evaluation statements. Two of the panels (H and J) ran out of time before they could undertake this part of the evaluation, and due to an oversight the researcher who had taken over the postal iterations while the project coordinator was overseas did not ask for these statements from the postal panels.

Personal evaluation statements were completed for the choice between the Dam and the Weir by members of Panels A, F, G and I. In addition, personal evaluation statements were completed for the choice between the Dam and Desalination by members of Panel B. In each of these cases, panelists were asked to write a short essay comparing the two alternatives under consideration in terms of the specified evaluation criteria, and to make a final judgment as to

- which alternative was more efficient
- which was more equitable

- which was more sustainable (*i.e.*, was in the best interests of future generations) and
- which was in the best overall interests of society.

The final judgments are presented in Table 6.3.

Assessment of the Evaluation

As in previous case studies, the objectives and scope of the study had to be re-defined, and several discussions had to be held to decide what research techniques would be most appropriate to this case. During the course of these discussions, for example, an important policy matter was explained that influenced the study design. This again demonstrates the crucial importance of holding discussions with the initiators of the study to determine just what is wanted, what is possible, and what should be done. Unlike many environmental evaluations, the proponent in this case (the Directorate of Water Affairs) allowed the research team considerable time to design the study and undertake needed investigations; in addition, much thought had already been given to alternatives and attempts at finding a compromise that would satisfy the various interested parties.

The Panel Evaluation Method went smoothly and had a high degree of acceptance by the participants and the client. The impact lists were considered comprehensive and clear, but some panelists felt uncomfortable with the idea of including among the benefits of a project the costs (of another project) that would be avoided. The impact report was well-received, and several panelists said it proved extremely useful as a reference tool while performing the tasks of the Significance Measurement Technique.

Panelists experienced several problems with applying the three evaluation criteria: in all cases it was done in rather a hurry at the end of the Delphi meeting, and there were considerable differences of opinion. Although the panelists generally felt that the layout of the personal evaluation statement assisted them in "thinking through" each criterion and then making trade-offs between the criteria, an analysis of the replies indicated that many respondents either did not understand the meaning of one or more criteria, or did not know how to apply them. Several panelists just listed pros and cons and did not come to any clear judgments; many statements were not completed and many responses could not be interpreted (which is why so many had to be classified as "uncertain" in Table 6.3). It is obvious that the format and instructions were not sufficiently clear, the criteria were not adequately defined (particularly the equity criterion), and insufficient time was allowed for applying the criteria. More time, better explanations and the use of an iterative procedure (such as was used to make the efficiency determination) are needed for this crucial task.

Because the central objective of the research for this dissertation was to develop and demonstrate an acceptable technique for judging the relative significance of lists of impacts to aid in the efficiency determination and to highlight major concerns, most of the effort for this case study (as well as for the other case studies) was directed at testing and improving the Significance Measurement Technique. As previously mentioned, ten panels evaluated impacts related to the Palmiet study. The following assessment focuses on applying the three tests to nine of the panels, which were specifically constituted for this purpose.[1] Five of these nine panels rated, ranked and weighted all four lists of impacts; the other four panels performed these operations for only two of the four lists (the ones concerned with comparing the Dam to the Weir). In the following sections, the evaluations of these panels will be analyzed in terms of the three tests mentioned above: the degree to which there is convergence with feedback, the pattern of the final distribution of responses, and the reliability of the results.

1 The tenth panel, Panel J - which was comprised of students doing a course in environmental studies - was a small panel which applied the Significance Measurement Technique as a class exercise. This panel was not originally intended to be part of the study. Nevertheless, it was later decided to include the student panel in part of the analysis - *viz.*, application of the test concerning replicability of results.

Convergence with Feedback

Appendix M presents, for each panel in turn, the standard deviations for group ratings of the various impacts on each list over each of three iterations. Unfortunately some of the panels varied in size over the three iterations, so that the measures of standard deviation are not always strictly comparable. Nevertheless, it can be seen that in most cases the extent to which panelist ratings differ decreases with each iteration; this indicates that the group response generally moves towards consensus with feedback. In fact, in 271 out of 285 cases the standard deviation of the third iteration was lower than that of the first. Moreover, although the third iteration of rating did not always result in greater consensus than the second, the third iteration generally resulted in greater consensus than did the second iteration: in 49 cases the standard deviation remained the same, but the third iteration produced greater agreement in 213 of the 236 cases in which there was a difference between these two iterations.[2]

In 178 cases (62%) there was a continuous decline in standard deviation over the three iterations of rating. In 14 cases (5%) the standard deviation for the third iteration was the same or higher than that for the first iteration. For the remaining 93 cases (33%), the standard deviation for the third iteration was lower than that for the first iteration, but in 27 cases (10%) the standard deviation for the second iteration was not lower than that for the first iteration, and in 66 cases (23%) the standard deviation for the third iteration was the same as or higher than that for the second iteration.

The fact that convergence with feedback has been demonstrated does not necessarily mean that group judgment has been improved. It is possible that some panelists change their rating simply because they feel uncomfortable that their rating is relatively far from the group mean. The technique is designed to draw attention to areas of greater disagreement amongst the panelists, and it seems reasonable to assume that those panelists whose rating is nearer the group mean will give less consideration to changing their rating than those who are further from the group mean. In addition, this latter group will often be at one extreme of the rating scale, so that there will be a greater chance of movement toward a less extreme position. Finally, the panelists at extreme positions will tend to search for reasons why their judgment should be changed in the direction of the group mean, and feel a subtle pressure to do so (even though their judgments are anonymous), simply because their attention is concentrated in that direction rather than in the opposite direction, and since many people find it psychologically uncomfortable to take a minority position.

Nevertheless, Dalkey *et al.* (1972) found in experiments with almanac-type data that a high degree of consensus was a good indicator of accuracy. There may therefore be little need to reconsider judgments for which there is relatively great agreement, whereas it is useful to direct attention toward those areas for which there is disagreement so that they can be re-considered. The object is to produce a better group judgment, and surely re-evaluation can contribute positively to that goal. It is important, however, to instruct the panelists in very strong terms to think independently and not change any judgments just to conform with the group thinking.

Distributions of Responses

Appendix N presents, for each impact list in turn, the histograms for the third (and final) iteration of rating by each panel. For the purposes of this analysis, a unimodal distribution has been defined as a distribution which is described by a curve with a single peak which falls away on both sides with no upturns that are more than one unit above the lowest measure on each side. A bimodal distribution has been defined as one in which the distribution involves a second peak of at least two units above the lowest measure on one side. Using this definition, a high proportion of the histograms in Appendix N have a single-peaked or unimodal distribution: of

2 There thus seems to be a strong case for conducting three iterations of rating, whereas two iterations of impact identification may normally be adequate. This latter point is indicated by the experience in all four case studies in which the Impact Identification Technique was applied, and is also supported by results reported in Richey *et al.* (1985a) (see Impact Evaluation in Chapter 5).

the 285 distributions of 3rd iteration ratings, 242 (85%) are considered unimodal. This indicates that panelists broadly share the same information and viewpoint (*e.g.*, there is no divergence of opinion between two groups of individuals within the panel). There are, however, a total of 43 twin-peaked or bimodal distributions, and more than half of the 41 impacts had at least one case of bimodal distribution.

Of the 41 impacts comprising the four lists, 16 (39%) had no bimodal distributions for their combined 96 distributions, but the remaining 25 impacts had from one to three distributions each. These bimodal distributions could either be due to different interpretations of the data or different value systems, but the fact that a high proportion of the impacts had unimodal distributions, and these were concerned with a range of issues dealing with a wide variety of values, indicates that the principal reason for the bimodal distributions was that the impact report did not present sufficient information to permit a clear interpretation of these impacts.

The incidence of bimodal distributions within the four lists ranged from 10% (6 of 60) for List Four (the benefits of Desalination compared to the Dam), to 19% (24 of 126) for List One (the benefits of the Dam compared to the Weir). For the other two lists, the incidence of bimodal distributions were 11% and 15% (see Table 6.4). The relatively high number of bimodal distributions for List One is likely due to the fact that the advantages of the Dam over the Weir are more subtle and probably more difficult to interpret than the differences between the other lists.

TABLE 6.4
Incidence of Bimodal Distributions for Each List

Alternative	Proportion of distributions which is bimodal	%
Dam vs Weir	24 of 126	19
Weir vs Dam	6 of 54	11
Dam vs Desalination	7 of 45	15
Desalination vs Dam	6 of 60	10

The incidence of bimodal distributions for panels A through E (which had evaluated all four lists) averaged 13%, while that for Panels F through I (which had evaluated only two lists) averaged 19%. Panels A, C and D had the lowest incidence of bimodal distributions 10%, 10% and 12% respectively), while Panels G, E and B had the highest (30%, 20% and 17% respectively) (see Table 6.5). Since there are no obvious differences between these two groupings of panels, it is not clear why one should have had more bimodal distributions than the other.

TABLE 6.5
Incidence of Bimodal Distributions for Each Panel

Panel	Proportion of distributions which is bimodal	%
A	4 of 41	10
B	7 of 41	17
C	4 of 41	10
D	5 of 41	12
E	8 of 41	20
F	3 of 20	15
G	6 of 20	30
H	3 of 20	15
I	3 of 20	15

The high proportion of unimodal distributions (85%) indicates that the information that was provided to the panelists pertaining to each impact was generally not subject to more than one interpretation. In addition, this result indicates that the panels were so constituted that a range of value systems was represented, rather than two or more groupings of persons holding extreme positions on the issues. Finally, the relatively low incidence of bimodal distributions in the final iteration indicates that the method was successful in avoiding polarization during the evaluation process.

Reliability of Results

Table 6.6 presents, for each of the four lists of benefits in turn, the average weight each panel gave to each impact. Table 6.7 presents correlation matrices which reveal, for each list, the degree of agreement between each pair of panels as to the relative significance of the benefits on that list. The product-moment correlation coefficient was calculated for the weights given each impact as a result of the ratio-scoring procedure. For example, in order to compare the similarity of judgments made by Panels A and B as regards the significance of impacts on List One (the benefits of the Dam in relation to the Weir), the average weights given each of the 12 benefits by the members of Panel A were compared to those given by the members of Panel B, and the correlation coefficient was determined to be 0.91 (see Table 6.7).

All nine panels evaluated Lists One and Two (Dam/Weir and Weir/Dam), but only five of the panels evaluated Lists Three and Four (Dam/Desalination and Desalination/Dam), resulting in a total of 28 separate evaluations involving the four lists. This meant that comparisons could be made between 36 pairs of panels for List One and 36 for List Two, and between 10 pairs of panels for List Three and 10 for List Four. Therefore a total of 92 correlation coefficients were calculated comparing average weightings given to the same list of impacts by two panels.

The results of these 92 correlations are summarised in Table 6.8. As can be seen, nearly half are greater than 0.9; 86 (93%) are greater than 0.7; and only 6 of the 92 are less than 0.7.

The highest correlations were for List Two (Weir/Dam), and the lowest were for List One (Dam/Weir). All six correlations under 0.7 were for List One, which was the longest list (14 items) and involved the most complex trade-offs; List Two was the shortest list (6 items), and involved comparatively simple evaluations.

Of the six correlations under 0.7 (all from list one), three involved Panel I, three involved Panel B, and two involved Panel D. An attempt to account for differences in the correlations between the panels was not successful. Because of budgetary and other limitations on the research design, it was not possible to control the possible variables of interest and there are too many variables to attribute higher or lower correlations to any one variable. Some of the ways in which the panels differed included:

- the number of individuals on the panel;
- whether the panels made a site visit;
- whether they performed the evaluation at a single meeting or by post;
- whether they were involved in defining the impacts to be evaluated;
- whether they did the evaluations prior to or after 1985;
- whether they were formed specifically for the purpose of the evaluation or consisted of a group existing for another purpose; and
- whether the members of the panel resided in the Cape Town area.

TABLE 6.6
Weightings Given by Each Panel to Each Benefit
(Final average normalised weightings for each panel, as used to determine correlation coefficients between panels.)

PANELS:		A	B	C	D	E	F	G	H	I
Benefits:	A	4,7	8,3	7,0	11,3	10,7	3,5	4,7	5,0	3,2
DAM vs	B	8,7	9,2	11,0	9,2	14,1	11,2	13,0	7,5	9,6
WEIR	C	8,7	9,8	13,8	16,0	9,4	14,8	14,2	13,3	15,0
	D	11,3	8,1	12,7	11,6	11,1	11,6	10,0	8,8	11,2
	E	1,9	1,0	0,9	2,3	0,3	2,3	3,8	2,6	1,6
	F	15,1	21,5	13,6	9,6	15,0	8,1	11,5	12,8	1,5
	G	3,0	1,6	3,7	5,2	4,3	5,0	4,4	7,6	6,4
	H	9,7	6,4	4,8	3,4	3,9	3,0	3,5	5,4	3,7
	I	1,7	0,7	1,3	0,3	1,5	3,5	3,3	3,4	3,7
	J	8,1	11,2	7,3	6,5	7,7	9,3	9,2	11,2	10,6
	K	15,6	18,4	17,2	13,2	14,5	15,6	15,6	14,1	15,9
	L	5,2	1,5	2,0	4,4	1,4	5,0	3,2	2,9	2,6
	M	2,3	1,6	2,1	2,8	2,3	2,2	0,8	2,8	2,7
	N	3,8	0,5	2,7	4,5	4,1	5,0	2,3	2,6	2,3
WEIR vs	A	2,5	0,6	3,4	5,4	0,0	3,0	4,7	4,0	2,9
DAM	B	23,8	21,5	14,6	17,6	20,8	14,4	16,5	24,3	19,2
	C	41,4	38,3	34,9	29,2	43,0	41,1	37,4	34,7	46,9
	D	3,5	8,7	8,8	9,8	6,3	4,8	5,8	10,5	7,5
	E	19,5	17,4	24,1	21,7	19,2	26,5	22,7	10,5	11,5
	F	9,3	13,5	14,1	16,5	10,7	10,2	12,8	16,0	12,0

PANELS:		A	B	C	D	E	
Benefits:	A	25,0	18,8	14,4	14,9	17,1	
DAM vs	B	18,6	16,1	19,0	14,1	24,6	
DESALINATION		C	15,5	9,0	14,8	14,8	12,5
	D	22,2	21,5	18,0	19,1	22,5	
	E	12,2	17,5	15,1	19,3	10,3	
	F	0,4	6,5	2,8	5,1	4,1	
	G	3,5	5,9	10,8	5,1	5,2	
	H	1,8	3,9	3,4	6,3	1,3	
	I	0,7	0,9	1,6	1,5	2,3	
DESALINATION		A	15,7	15,5	16,4	14,5	10,3
vs DAM	B	2,5	0,7	0,6	2,9	1,3	
	C	4,8	4,3	6,0	6,2	5,0	
	D	19,6	28,9	17,3	13,7	23,5	
	E	9,1	6,9	9,1	9,1	10,2	
	F	4,6	7,6	4,7	6,5	3,8	
	G	10,5	10,0	16,0	11,2	11,8	
	H	13,7	7,1	13,7	9,9	14,4	
	I	13,8	9,8	9,6	16,8	14,0	
	J	1,4	2,4	2,5	4,8	2,1	
	K	0,6	0,6	0,8	1,5	0,2	
	L	3,8	6,3	3,3	2,9	3,3	

TABLE 6.7
Correlation Matrices Showing Degree of Agreement between Each Pair of Panels

DAM vs WEIR

	A	B	C	D	E	F	G	H	I
A		0,91	0,89	0,68	0,82	0,73	0,80	0,82	0,53
B	0,91		0,88	0,69	0,88	0,67	0,81	0,87	0,46
C	0,89	0,88		0,90	0,92	0,90	0,94	0,90	0,74
D	0,68	0,69	0,90		0,82	0,83	0,83	0,78	0,73
E	0,82	0,88	0,92	0,82		0,75	0,85	0,78	0,55
F	0,73	0,67	0,90	0,83	0,75		0,94	0,85	0,91
G	0,80	0,81	0,94	0,83	0,85	0,94		0,90	0,81
H	0,82	0,87	0,90	0,78	0,78	0,85	0,90		0,75
I	0,53	0,46	0,74	0,73	0,55	0,91	0,81	0,75	

WEIR vs DAM

	A	B	C	D	E	F	G	H	I
A		0,98	0,92	0,93	0,99	0,94	0,96	0,91	0,94
B	0,98		0,93	0,95	0,99	0,92	0,95	0,95	0,96
C	0,92	0,93		0,98	0,95	0,99	0,99	0,77	0,87
D	0,93	0,95	0,98		0,95	0,96	0,97	0,82	0,86
E	0,99	0,99	0,95	0,95		0,95	0,97	0,92	0,96
F	0,94	0,92	0,99	0,96	0,95		0,99	0,75	0,88
G	0,96	0,95	0,99	0,97	0,97	0,99		0,82	0,91
H	0,91	0,95	0,77	0,82	0,92	0,75	0,82		0,95
I	0,94	0,96	0,87	0,86	0,96	0,88	0,91	0,95	

DAM vs DESALINATION

	A	B	C	D	E
A		0,90	0,87	0,85	0,91
B	0,90		0,86	0,92	0,86
C	0,87	0,86		0,88	0,90
D	0,85	0,92	0,88		0,78
E	0,91	0,86	0,90	0,78	

DESALINATION vs DAM

	A	B	C	D	E
A		0,86	0,93	0,91	0,95
B	0,86		0,79	0,71	0,86
C	0,93	0,79		0,84	0,88
D	0,91	0,71	0,84		0,83
E	0,95	0,86	0,88	0,83	

TABLE 6.8

	< 0.7	0.7 +	0.8 +	0.9 +
LIST ONE (DAM/WEIR)	6	30	23	9
LIST TWO (WEIR/DAM)	0	36	34	29
LIST THREE (DAM/DESALINATION)	0	10	9	4
LIST FOUR (DESALINATION/DAM)	0	10	8	3
TOTAL	6	86	74	45
(PERCENTAGE)	(7%)	(93%)	(80%)	(49%)

Table 6.9 summarizes the major ways in which the panels differed:

TABLE 6.9
Grouping of Panels by Shared Characteristics

PANEL CHARACTERISTICS	A	B	C	D	E	F	G	H	I
1. Panelists made a site visit									
. yes	+	+				+	+	+	+
. no			x	x	x				
2. Panel defined impacts									
. yes	+	+							
. no			x	x	x	x	x	x	x
3. Evaluation carried out:									
. by post & at meeting	+	+							
. by post only			x	x	x				
. at meetings only						o	o	o	o
4. Panel size:									
. 10-15 members	+	+	+	+					
. 17-22 members					x	x	x	x	x
5. Panel composition									
. selected, multidisciplinary	+	+	+	+	+				
. existing group accepted						x	x	x	x
6. Domicile of panelists									
. in or near Cape Town	+	+							
. throughout SA			x	x	x	x	x	x	x
7. Date of evaluation:									
. 1983/1984	+	+	+	+	+				
. 1986/1987						x	x	x	x

It can be seen that the Panels which share at least six of these seven characteristics are A and B (Group 1), C, D and E (Group 2) and F, G, H and I (Group 3). In addition, all of the Group 3 panels are larger than those of Groups 1 and 2. Of these three groups of panels, each differs from each of the others in respect of four of the six characteristics (and Group 3 differs from the other two in respect of size). One might therefore expect higher correlations for judgments within these groups than between the groups. But reference to Table 6.10 indicates that panels within groups are not better correlated than panels between groups; therefore it is not possible to identify any characteristics or groups of characteristics that might influence reliability.

TABLE 6.10
Correlation Matrix of Aggregated Scores: Panels A - J

	A	B	C	D	E	F	G	H	I	J
A		0,912	0,906	0,867	0,946	0,917	0,936	0,908	0,888	0,928
B	0,912		0,891	0,848	0,917	0,860	0,919	0,928	0,835	0,849
C	0,906	0,891		0,922	0,924	0,956	0,976	0,863	0,862	0,893
D	0,867	0,848	0,922		0,867	0,907	0,932	0,863	0,841	0,814
E	0,946	0,917	0,924	0,867		0,924	0,951	0,904	0,898	0,912
F	0,917	0,860	0,956	0,907	0,924		0,979	0,829	0,908	0,932
G	0,936	0,919	0,976	0,932	0,951	0,979		0,887	0,909	0,904
H	0,908	0,928	0,863	0,863	0,904	0,829	0,887		0,919	0,813
I	0,888	0,835	0,862	0,841	0,898	0,908	0,909	0,919		0,888
J	0,928	0,849	0,893	0,814	0,912	0,932	0,904	0,813	0,888	

Correlation matrix, correlation coefficients calculated using normalised group weightings for all lists.
Top left section (panels A through E) calculated over FOUR lists; remainder of table over TWO lists only (dam vs weir and weir vs dam).

In addition to the nine panels already mentioned, a small student panel was asked, as part of their instruction programme, to undertake evaluations of Lists One and Two, and the results were compared with those of the regular panels. This student panel, designated Panel J, was the only panel comprised of full-time students; in addition, these students were all enrolled in the same course (a Masters degree programme in environmental studies). Panel J may therefore be regarded as more homogeneous than the other panels, and the judgments of this panel may be expected to be correlated relatively poorly with the judgments of the other panels. This panel did, however, share with Group 3 (Panels F, G, H and I) all six of the characteristics listed above: it made a site visit, performed the evaluation at a meeting, was not involved in defining the impacts, performed the evaluation after 1985, was not selected to ensure a diverse composition, and the members resided in different parts of South Africa. Panel J differed from the Group 3 panels in two major respects: size (being considerably smaller), and natural affinity (being a group of full-time students with sufficiently similar interests to be enrolled in the same degree programme). If there are any high correlations, one would expect them to be with the panels of Group 3.

Panel J does have a high proportion of relatively weak correlations: Table 6.11 shows that none of the nine correlations for List One (Dam vs. Weir) are above 0.8, and six (67%) of these are below 0.7. By contrast, 23 of the 36 correlations between the other panels for List One are above 0.8, while only six (17%) are below 0.7. Nevertheless, Panel J is well-correlated with other panels for List Two (Weir vs. Dam): the lowest correlation is 0.83 and the remaining correlations are all above 0.9. This compares favourably with the correlations achieved by the other panels for List Two. In addition, Panel J does not have higher correlations with Group 3 panels (F, G, H and I) than with panels from the other two groups.

The comparison of Panel J with other panels indicates that replicability may be improved if the panel is comprised of a heterogeneous group of persons. This could be due to the greater variety of perspectives and value systems represented in a heterogeneous group. But in the foregoing analysis it was not possible to identify other panel attributes that may be important to achieving replicability for the reason mentioned previously - *viz.*, there was no opportunity to control the variables of interest. Nonetheless, the judgments of all panels seem reasonably well-correlated, with the exception of Panel J (which was a relatively small and homogeneous panel), and to some extent Panel I. This indicates that none of the seven characteristics listed above may be factors which adversely affect replicability, provided that the panel is above some minimum size.

TABLE 6.11
Correlation of Panel J's Weighting Scores with Those of Panels A-I

DAM vs WEIR

	A	B	C	D	E	F	G	H	I
J	0,76	0,62	0,77	0,61	0,63	0,71	0,64	0,62	0,51

WEIR vs DAM

	A	B	C	D	E	F	G	H	I
J	0,95	0,94	0,95	0,91	0,97	0,97	0,98	0,83	0,95

CASE STUDY 5

Background

The principal research objective of this case study was to assess the possible biasing effect of a project coordinator on the results of group forecasting and evaluation. A second objective was to test a variation of the Impact Identification Technique which did not rely on the post, and which permitted the task of identifying and defining impacts to be accomplished within a very short time.

The study concerned a proposed extension of a coastal holiday township. Infanta is a village on the west bank of the Breede River mouth in the southern Cape. The area is well-known as a popular retirement and holiday area which offers a variety of recreational opportunities associated with its scenic river and coastal setting. In 1981 a developer had submitted an application for a township extension on a hill above the present township of Infanta. This proposal had met with objections from existing Infanta residents, who were concerned about crowding and changes to the character of the community, and by conservationists, who were concerned about aesthetic and ecological impacts to the area. Both residents and conservationists claimed that the proposed township extension of 100 plots would result in a population that would exceed the recreational carrying capacity of the area.

As part of a project to develop and test various evaluation methods for the South African Human Sciences Research Council, researchers from the Environmental Evaluation Unit at the University of Cape Town used the Panel Evaluation Method to identify the advantages and disadvantages of the proposed township extension, and to evaluate the relative significance of these advantages and disadvantages. The issue appeared to be of considerable importance to local residents, but of only moderate or low importance to the region or the nation. The study was seen by the University of Cape Town researchers as an opportunity to demonstrate the flexibility of the Panel Evaluation Method to accommodate the scale and importance of any contentious environmental issue, and to test the usefulness of the procedure under conditions when few resources were available for conducting an evaluation and limited time was available for obtaining the results. But the major object of the study was to investigate the question as to whether the Impact Identification Technique and the Significance Measurement Technique produced results that were replicable.

Specifically, there was concern about the extent to which the project coordinator might influence the results of impact identification and evaluation. The project coordinator obviously plays a major role in the procedure by directing the selection of panelists, preparing documentation, organising site visits, and communicating with panelists before and during the evaluation procedure (Richey *et al.*, 1985a:137). During the first case study (see Case Study 1 in Chapter 4), impacts identified and defined by the project coordinator had been interpreted in different ways by different panelists, and a few panelists had indicated that some impacts overlapped, while other potential impacts had been overlooked. This obviously made it impossible to conduct a proper evaluation. One interesting question is whether two panels, each working with a different project coordinator in otherwise similar circumstances, might generate very different lists of impacts, or might score (or weight) impacts very differently. Another interesting question is whether the panels could produce more comprehensive and better defined lists of impacts than could individual analysts who were working independently, even if they had some special expertise in impact assessment and greater knowledge of the study area.

The Study

In order to investigate the possible biasing effect of the role of the project coordinator it was decided to assemble two panels which would go through identical forecasting and evaluation exercises but under different project coordinators. In addition, two individuals trained in environmental studies and intimately familiar with the study area were asked to independently identify and define the impacts of the proposed township extension so that the lists each produced could be compared with those of the other, and with those of the panels.

The principal research objective was to determine whether the two panels, operating under different project coordinators, would identify and define impacts that were essentially the same. A second objective was dependent on accomplishment of the first: if the two panels produced lists of impacts that were recognizably similar, then an analysis would be made as to whether there was also agreement as to the relative significance of each impact. The third objective was to assess whether the Delphi panels would produce a clearer and more comprehensive list of impacts than individual experts working separately but given the same basic information.

The approach taken to determine whether impact definitions produced by the two panels were sufficiently similar so as to be interpreted in the same way was to ask three research associates to independently compare the definitions and separately indicate which impacts corresponded and which had no counterpart. The researchers then conferred to see whether they were agreed or not.[3] The same researchers also made similar comparisons of the lists produced by the two experts against those of the panels. The method used to assess the degree of agreement on impact scores or weightings was to calculate the product-moment correlation coefficient.

Panelists were selected by the principal researcher in consultation with other members of the research team.[4] Final selection was based on the research team's judgments as to the suitability of individual panelists in terms of disciplinary orientation, relevant expertise, and perceived neutrality or objectivity pertaining to the outcome.

The two panels visited the site and conducted their respective evaluations on different weekends in November, 1986. There were 11 persons on each panel, and support staff was limited to three per evaluation. Each panel spent a weekend in rented accommodation in the

3 Appendix O presents the consensus on impact correspondence for each of two iterations by the two panels.

4 The chain-referral technique was not used due to time constraints, and since the study was being conducted as an academic exercise (*i.e.*, there was no need to ensure the composition of the panel of the panel was acceptable to the decision makers or concerned parties).

vicinity of the proposed development. The first day was spent in reading briefing materials, accomplishing a site visit, and identifying and defining all the social costs and benefits of the proposal. The second day was spent in judging the relative importance of the costs/benefits.

The panels convened under similar circumstances, and were briefed and given a site visit by the principal researcher. The evaluation tasks on the different weekends were guided by two different project coordinators (each assisted by a different person), but using the same general approach. The project coordinators consulted the principal researcher on questions related to the project proposal and the Panel Evaluation Method, but care was taken not to discuss anything that might influence the impact identification and definition process. In addition, the project coordinator and panel members of the second session were not informed of any of the results of the first session.

Both panels were comprised of individuals with similar backgrounds, and the same procedures were used for both panels. The panelists were given individual briefing documents before the weekend session that described the proposed development and the nature of local objections to the proposal.

On the first morning of the weekend session, the panelists were taken to the site. Maps and notebooks were provided, and panelists were encouraged to ask questions and take notes which would be useful in formulating impact definitions (*i.e.*, define costs and benefits of the proposal) in the first session.

On returning to the meeting room, the panel was briefed on the procedure that would be used for forecasting and evaluating impacts, and the project coordinator then asked each panelist to individually and without discussion list project costs and benefits on separate colour-coded forms. The panel was then adjourned until after lunch but panelists were asked not to discuss the proposal or its impacts with anyone. The project coordinator and an assistant then went through the impact forms and synthesized impact definitions under banner headings (see Appendix O). The object was to combine statements produced by different individuals but that addressed essentially the same issue into a single, concisely-worded statement, and to combine those costs or benefits which seemed to overlap or interact so that impact definitions would be discrete, clear, and unambiguous.

The rephrased statements were then written out on large sheets of paper and posted around the meeting room, and panelists were brought back in to scrutinize the statements for completeness and accuracy. Panelists were asked to consider whether any statements could be further combined (or whether any should be split), to suggest new wording for any statement not satisfactorily defined, and to offer totally new statements for any impacts not previously identified. Any suggestions were to be made anonymously in writing. Some panelists did submit new impact forms, and the panel was then adjourned for the day while the project coordinator and assistant reviewed the suggestions and drafted new impact definitions.

On the following morning the panel convened and was presented with the revised impact definitions (see Appendix O). Panelists were first given a final opportunity to refine definitions of costs and benefits. Because of time constraints and the relatively minor and uncontentious nature of the changes to be made at this stage, no attempt was made to preserve anonymity in the exchange of opinion that led to modifications, and general consensus was easily obtained as to whether to accept or reject proposed changes.

An evaluation exercise was then conducted to determine the importance of each cost relative to every other cost, and of each benefit to every other benefit. This exercise involved, for each of the two lists (*i.e.*, of costs and of benefits), the rating of each item on a scale of 1 to 7 (1 signifying "of no importance" and 7 "of extreme importance").

The results of the group ratings were fed back to the panel in the form of hand-tabulated histograms (computer facilities were unfortunately not available), and panelists were then asked to reconsider their ratings, submit any (anonymous) comments of a factual nature that might help establish the importance of a particular impact, and re-rate the impacts. After three iterations of ratings for each list, panelists were asked to individually rank the impacts in order

There are no pages 170-172 because of repagination of importance and then evaluate their relative importance. This was done by assigning the number 10 to the lowest ranked impact that was deemed to have any significance (*i.e.*, that was above the "threshold of significance"), and then scaling every other impact against this "threshold impact" (see Impact Evaluation in Chapter 5).

In the meantime, two environmental analysts who were intimately familiar with the Infanta area were each conducting independent evaluations. Both were given the same briefing materials that were received by the panelists, which included a description of the proposal and the affected environment. Each analyst was asked to identify and define the impacts that could result, and submit a brief report discussing the relative significance of these impacts.

The Results

One of the independent analysts identified 3 positive and 7 negative impacts, whereas the other analyst identified 8 positive and 20 negative impacts. Each of the analysts omitted potentially major impacts that the other had listed, and neither of the lists were as comprehensive or well-defined as those compiled by the two panels.

The panels essentially agreed as to the identity and nature of the impacts that would result from implementing the proposed township extension. Panel 1 and Panel 2 identified 11 and 12 negative impacts respectively which were basically equivalent, although each panel identified one (relatively minor) negative impact which the other panel had not mentioned. While Panel 2 identified several more positive impacts than did Panel 1 (11 vs. 6), only three did not correspond with the impacts identified by Panel 1, and all three could be regarded as relatively minor or trivial concerns.

The principal positive impacts of this action were determined to be better recreational facilities, employment prospects, and infrastructure and services for local residents. The principal negative impacts were determined to be general degradation of the area (in terms of aesthetics, security and community character), losses to marine and estuarine systems, and recreational congestion.

All three research objectives were accomplished, and the results of the study were positive:

- the panels produced lists of impacts that were very similar in content and meaning;
- the panels made similar judgments as to the relative importance of these impacts; and
- the lists of impacts generated by each panel were more comprehensive and the impacts were defined more clearly than those of either expert.

In addition, the work of each panel substantially met the other tests devised for determining whether the Significance Measurement Technique improves groups judgment, *viz.*, convergence with feedback, and unimodal distribution of responses.

While the two panels basically agreed as to what impacts would result from the project, the wording of impacts obviously differed, and in some cases one panel would define two impacts (and in one case even more) that the other panel had defined, in more general terms, as one impact. In order to assess replicability, three research associates, working separately, judged which impact definitions of the two panels corresponded and which had no counterpart or were not really comparable (see Appendix O). When these judgments were compared, only three slight differences were noted; these were concerned with very minor impacts, and appeared to be due to different interpretations of ambiguous words and phrases.

Another important finding was the fact that although the panels eventually produced essentially the same lists of costs and benefits, there was little agreement on the first round of impact identification. A comparison of the initial lists generated by each panel (and synthesized by the respective project coordinators) revealed a surprising <u>lack</u> of correspondence in impact identification and definition. Panel 1 listed three positive impacts and six negative impacts that were not listed by Panel 2, and Panel 2 listed three positive impacts and sixteen negative impacts that were not listed by Panel 1. Perhaps even more surprising, however, was the high degree of correspondence between the panels that subsequently developed in the revised lists. After this second iteration, all of Panel 1's positive impacts were listed by Panel 2, and only three relatively insignificant positive impacts listed by Panel 2 were not listed by Panel 1. In addition, each panel identified all but one (relatively insignificant) negative impact listed by the other panel.

Further analysis of these results revealed that the second iteration had served to identify related concerns, so that they could be grouped and their common nature clarified; in other words, relatively trivial or related impacts became subimpacts which when taken together constituted truly independent impacts (*i.e.*, they did not overlap or interact). Thus while the second iteration of impact identification did not add many new impacts or substantially redefine the original impacts, it did help to organise the original impacts into "categories" of impacts; this in turn made it possible to articulate more broadly-defined impacts. In addition to being more substantive in nature, these broad impacts could be clearly distinguished from one another so that comparative evaluations could be made without the confusion or double counting that could result if impact statements interacted or overlapped.

A major conclusion of this analysis is that both the iterative nature of the Impact Identification Technique, and the guidance provided by the project coordinator, can greatly improve the quality of the evaluation by creating a list of impacts that is more manageable, more relevant, and more clearly understood. The true impacts become more clearly defined and focused because of the re-think and re-organisation that is required by the technique. This result has more general and highly significant implications for handling controversial resource allocation proposals: if iterative procedures are not adopted in planning, assessment and evaluation, there is much greater potential for confusion and polarization; in addition, it will be less likely that superior proposals will be discovered, that potential impacts will be adequately understood, and that the evaluation will be accurate and well-received.

The two experts produced lists of impacts which were, in the judgment of the three research associates, not as comprehensive, well-defined, or well-ordered as those of the panels. Some of the impact definitions were too broad or general, others overlapped or were repetitious, and several were rather ambiguous or muddled. Each expert failed to list impacts that the other had identified, and both omitted impacts (some major) that were identified by the panels, while neither identified any impacts that had been missed by either of the panels. For example, one expert did not identify any impacts related to increased costs for the local authority to provide services, and the other did not identify any impacts concerning changes in the character of Infanta village. And neither expert identified any impacts related to the terrestrial environment (e.g., loss of lowland fynbos, introduction of alien vegetation, and erosion problems).

Since there was a high degree of correspondence between the final impact definitions produced by the two panels, it was possible to compare significance evaluations made by the two panels. Comparison of importance scores or weights was done by combining the impact scores of one panel as necessary to make them comparable to the impact scores of the other panel. For example, since Positive Impact A of Panel 1 was judged to be equivalent to Positive Impacts A and B of Panel 2, the scores assigned to the latter were summed and compared to the score given to the former. Table 6.12 presents a listing of the impacts identified by Panel 1 with the comparable impacts identified by Panel 2, and their respective associated weights or importance scores. The product-moment correlation coefficient was then calculated for the scores derived for the items on the modified lists. The correlation coefficient for these results is 0,84 for the list of positive impacts and 0,96 for the list of negative impacts, for a combined correlation of 0,91.

Thus there is a strong positive correlation between the judgments of the two panels as to the relative significance of impacts associated with the proposed township extension. This indicates that two panels working under different project coordinators can substantially agree not only on the identity but the relative importance of impacts.

TABLE 6.12
Comparison of Weightings Assigned by Two Panels to Equivalent Impacts

6.12a Positive Impacts

PANEL 1 IMPACTS	SCORE		PANEL 2 IMPACTS	SCORE
1A	23	<->	2A+2B	22
1B	23	<->	2I	13
1C	26	<->	2G	25
1D	4	<->	2E+2F	10
1E	10	<->	2D	18
1F	13	<->	2K	5
-	0	<->	2H	2
-	0	<->	2J	3
-	0	<->	2C	0

6.12b Negative Impacts

PANEL 1 IMPACTS	SCORE		PANEL 2 IMPACTS	SCORE
1A	15	<->	2F	16
1L+1B	14	<->	2G	9
1C	0	<->	-	0
1H+1D+1J+1K	38	<->	2A+2E+2I+2C	37
1E+1F	21	<->	2H	18
1I	3	<->	2D	10
-	0	<->	2K	2
1G	9	<->	2B+2J	9

6.12c Correlation of Adjusted Weighting Scores

Regression Output:	R squared	Correlation
Positive Impacts:	0,70	0,84
Negative Impacts:	0,93	0,96
Combined lists:	0,82	0,91

The results of this study indicate that two panels can, under the guidance of different project coordinators, conduct evaluations that will produce essentially the same results. Perhaps of greatest importance is the finding that different panels can independently identify the same impacts of a proposal (with the exception of very minor or rather spurious "impacts"), and define these so that they can be recognized as the same impacts, if there is more than one iteration of assessment. Furthermore, it appears that this agreement might not be possible without the presence of a project coordinator to ensure a careful reconsideration of how to define and organise the potential impacts. This suggests that a single iteration of impact identification and definition would not be adequate, and that even with more than one iteration two unsupervised panels might produce lists of impacts which could differ substantially.

The general conclusion drawn from these results is that a coordinator's biasing influence on panel judgments can be rendered slight and insignificant if the coordinator scrupulously follows the Panel Evaluation Method, and is conscious of the importance of playing a neutral role throughout the evaluation process. In fact, it appears that the project coordinator can have a beneficial influence on panel judgments by stimulating and facilitating the re-definition and re-evaluation processes which are so important to quality judgments. What is important is that coordinators are well-trained and sensitive individuals capable of answering questions and dealing with other individuals without imparting their own bias to panel members.

In addition, it appears that judgments made by panelists using systematic forecasting and evaluation procedures (such as the Impact Identification Technique and the Significance Measurement Technique) can be superiour to those made by "experts" trained in a relevant discipline and who are even more knowledgeable about the area of concern than are the individual panelists. The panels generated a clearer and more comprehensive list of costs and benefits, and accomplished a more rigorous evaluation of these costs and benefits, then did the individual experts, and all members of the research team agreed that the information provided by the panel would have proved more useful than that provided by the individual experts. The Panel Evaluation Method would thus be helpful, particularly in cases when a formal Environmental Impact Assessment cannot be done, to provide guidance for decision makers and improve the final resource allocation decision.

Assessment of the Evaluation

Two of the key elements of the Panel Evaluation Method - the Impact Identification Technique and the Significance Measurement Technique - proved to be flexible and cost-effective in this application to an issue of local importance which might not normally be allotted sufficient resources to conduct a proper Environmental Impact Assessment, and results were obtained in a very short time. The lack of computer-processing equipment and other technological aids did not prove to be a serious handicap.

A major failing was that panelists were not properly briefed on the Panel Evaluation Method before the meeting. One member of Panel 1 did not accept the Delphi concept and proved to be a somewhat disruptive influence, and was nearly obstreperous enough to undermine the entire exercise. Uncooperative or unsympathetic individuals should not be invited to serve on a Delphi panel, and pre-selection briefings and interviews should be given after concerned parties have approved panel nominees and before invitations to serve on the panel are issued.

An opportunity was missed to test whether panelists can relate the importance of a benefit on one list to that of a cost on another list, to confirm that the two lists can be directly compared in terms of significance, and a determination made as to whether costs exceed benefits or vice versa.

Although the three research associates agreed that impacts on the respective lists of the two panels were sufficiently similar to be considered essentially the same impacts, the technique used to make this determination was very subjective and so quite unsatisfactory. Such judgments are exceedingly difficult due to the nuances of words and phrases, and the fact that one panel might list more details than the other panel in describing impacts. Individuals invariably understand slightly different things by the same words, and some individuals are bound to have more information than others.

It must be accepted that any form of communication is extremely difficult, even when dealing with relatively simple matters, and correspondence of views is obviously never going to be exact. Nevertheless, it is the overall understanding or impression that is important. While specific interpretations of statements appeared to differ in this case (such as exactly what was meant by "employment opportunities"), the underlying concepts seemed to be shared (*e.g.*, temporary employment for local labour during construction, and seasonal employment for local labour in the formal and informal sectors after construction), and perhaps this is all that is necessary. Everyone can be expected to have slightly different conceptions of an impact, and certain aspects will inevitably be emphasized in one person's mind while other aspects will dominate in another's mind. This is all the more reason to employ a group evaluation procedure such as the one presented in this dissertation.

The greater correspondence noted for the second iteration may seem somewhat spurious since the "odd" impacts are grouped with impacts which were later determined to be interrelated. The grouping or aggregation has apparently "masked" some of the differences, but in fact these "differences" turned out to be various aspects of larger (and truly "independent") impacts.

For example, during the first iteration of the Impact Identification Technique, an impact identified by Panel 2

> "The new development might attract the wrong type of people" (*ie., people who are insensitive to nature)"

was not identified by Panel 1. In the second iteration, this specific impact was subsumed under an impact labeled "Change in Community Character", and this new, overarching impact was also identified in the second iteration by Panel 1, and labeled "Change in Character of Existing Infanta Village". While each panel identified different elements that would contribute to this broader impact, the ultimate issue of concern to both panels was the change in nature of the existing community.

The one instance in which several impact statements had to be combined (four for each panel) was due to differences in terminology and ways of conceptualizing impacts. Questions pertaining to aesthetics, community character, and security can overlap with one another. For example, the introduction of "undesirable elements" can affect all three, so one panel might list this problem under security and another under community character.

The final differences between the two panels are still not very serious; it is like two paintings of the same scene: the major components are there even if the details differ, and what is important for evaluation is that the major components are recognized and described so that they can be compared to one another and an adequate evaluation can be conducted.

CASE STUDY 6

Background

The principal research objective of this case study was to further evaluate the threshold of significance concept. Of particular interest was the question as to whether the threshold of significance for a list of costs may be regarded as equivalent to the threshold of significance for a list of benefits. If so, and if the present discounted value of a proposal has been weighted along with other impacts, then the efficiency determination can be made by simply comparing the sums of the weights given to the costs and benefits, and seeing which is greater.

Other objectives of the study were to test certain variations of the procedures used in the Delphi meeting, and to further demonstrate the general flexibility and applicability of the Panel Evaluation Method.

The study concerned a highly controversial road proposal in an urban community called Sandton. Sandton is an affluent residential area within the Johannesburg metropolitan area. The community has a rapidly growing commercial centre, and planners have predicted that this growth will continue, mainly as a result of corporate headquarters moving in from the overcrowded Johannesburg central business district.

Sandton is well served by north-south arterials linking Johannesburg and Pretoria, but there is only one major east-west arterial, and it passes north of the Sandton area. In the Sandton Traffic Master Plan of 1970, city planners and engineers presented proposals that addressed the problem of future traffic congestion, particularly commuters and shoppers transiting the area in an east-west direction.

The Sandton Town Council felt that there was a clear need for a new east-west arterial through Sandton to link two major north-south highways through the area. After preliminary investigations by consulting engineers, the "South Road extension" route was selected and land was acquired along the proposed corridor.

But many residents and a number of interest groups objected to the proposed road. Much of the opposition was generated by the feeling that a new road through this corridor would significantly reduce the amount of open space in Sandton, and would also lower the quality of the residential areas through which it would pass. Alternative corridors were suggested that would be less damaging to important environmental elements, foremost among which were the Sandton Field and Study Centre and the River Club golf course. Many people felt that the road was not even needed, and suggested that if traffic congestion did eventually become a serious problem existing roads could always be upgraded.

Between 1971 and 1987 nine separate studies were undertaken to investigate the feasibility and desirability of a new east-west link road. Most of these studies were concerned with applying technical and economic criteria to the problem, and this did not satisfy many of the opponents to the proposal. In 1987 the controversy surrounding the road issue was still raging, and if anything opposition to the road was greater than ever. The residents of Sandton had become even more polarized in their support for or against the proposed road. The opponents claimed that

- there had never been a proper enquiry into their concerns
- they had not even been given an opportunity to make their concerns known
- officials had not been fully candid or forthcoming with information
- the need for the road had still not been established
- promising alternatives had not been adequately considered
- the environmental impacts had not been properly examined.

In 1987 the Sandton Town Council appointed a special steering committee to investigate all the reports from these studies, and this committee then authorized still another study to re-examine the need for the road. When the report from this latest study was submitted, the committee concluded that a major arterial along the South Road corridor was indeed necessary, but a full environmental assessment should be done to select the most suitable alignment within the corridor. The Environmental Evaluation Unit of the University of Cape Town was commissioned to undertake this study in June 1988.

The Study

The study team from the Environmental Evaluation Unit spent considerable time clarifying the terms of reference with the project's sponsors. Since there was great opposition to the South Road corridor, it was eventually agreed that the null option could be compared to the best alternative alignment found within the South Road corridor. It was decided to do this indirectly, however, by considering whether the costs of the best alignment would exceed the benefits. In addition, it was to be assumed that the new road was to be evaluated from the perspective of the people who live and work in Sandton, and that Sandton would pay for the entire cost of the road.

The general study plan was as follows:

- review all existing data pertaining to the road proposal;
- actively solicit public comment to identify the major issues and alternatives;
- initiate investigations needed to assess and evaluate the issues and alternatives; and
- apply the Panel Evaluation Method to identify the preferred alternative.

After the initial data gathering and review was accomplished, a public participation programme was initiated. Representatives of special interest groups were identified and contacted to ensure that the concerns of the major affected parties were clearly understood. Advertisements and articles were placed in the local media to encourage discussion of the issues, and brochures which explained the study and invited comment were widely distributed. Members of the general public were invited to telephone or visit the study team to discuss their concerns and offer suggestions, and this information was systematically collected and used to guide further investigations.

A total of eight basic alternatives or "preliminary proposals" (in addition to the null alternative) were identified as a result of data gathered from the public and Sandton Town Council. These preliminary proposals were then assessed using the "Framework Approach", a technique for organising data sets in a presentational framework that is easy to read and understand (Leitch, 1979). The technique involves identifying the major alternatives, categories of effects and affected groups, and then displaying tables which contain short descriptions of the effects each alternative will have on each group (see Figure 6.2).

The study team met with a group of consultants and, using the framework that had been prepared, discussed the merits of the eight preliminary proposals. This assessment team concluded that five of the proposals could be eliminated from further study because of one or more shortcomings, and that a more detailed assessment and evaluation should be done of the three remaining alternatives: the "final proposals". The three final proposals, which were all different alignments within the South Road corridor, were known as Routes 2, 3, and 4.

Several experts were then engaged to undertake studies to provide more information on the final proposals. Two types of studies were conducted. The first type of study was to identify viable mitigation measures for certain impacts. The second type of study was to provide information needed to evaluate the significance of potential impacts, and to judge the viability and desirability of the final proposals. These data would be used to further refine the final proposals (with agreed mitigation included as part of the planned action), and to prepare an impact report that would be used to brief a panel that was to conduct a formal evaluation of the final proposals.

In accordance with the brief given by the Sandton Town Council steering committee, the formal evaluation was to be directed at answering two questions:

- Which of the three final proposals best meets the evaluation criteria?
- Do the benefits of the "preferred proposal" outweigh the costs?

An evaluation panel of fourteen persons was selected using the chain-referral technique. All of these persons were then involved in applying the three techniques of the Panel Evaluation Method. (One panelist was not able to attend the Delphi meeting to evaluate the impacts and apply the selection criteria.)

GROUP 1: TRAVELLERS

SUB GROUP	EFFECT	UNIT	CONCEPT 1 SRE ROUTE 1	CONCEPT 2 SRE ROUTE 2	CONCEPT 3 SRE ROUTE 3	CONCEPT 4 SRE ROUTE 4	CONCEPT 5 Republic Rd -Sandton Dr.	CONCEPT 6 Upgrading Ballyclare Dr	CONCEPT 7 Republic — SRE	CONCEPT 8 Selected Upgrading	NULL OPTION	COMMENTS
ALL VEHICLE TRAVELLERS	BENEFITS FROM SAVINGS IN VEHICLE KILOMETRES (1986 DATA)	Rm	GREATER THAN SRE ROUTE 3, AS THE ROUTE IS SHORTER	GREATER THAN SRE ROUTE 3 AS THE ROUTE IS SHORTER	58.1	VERY SIMILAR TO SRE ROUTE 2	LOWER THAN FOR CONCEPT 3 AS THE DISTANCE SAVED IS LESS	51.9	VERY SIMILAR TO SRE ROUTES 1 TO 4	0	0	PRESENT WORTH OF BENEFITS OVER A 22 YEAR STUDY PERIOD ASSUMING A DISCOUNT RATE OF 6% P. A.
	TIME SAVINGS EAST—WEST MOVEMENT		HIGHEST TIME SAVINGS IN THE LONG TERM DECREASE IN TIME SAVINGS FROM 1 TO 4 →	AS PER 1	AS PER 1	AS PER 1	REDUCED TRAVELLING TIME IN THE SHORT TERM (0 TO 5 YEARS)	LONGER TRAVELLING TIME IN THE SHORT TERM (0 TO 5 YEARS)	REDUCED TRAVELLING TIME	REDUCED TRAVELLING TIME IN THE SHORT TERM	NO TIME SAVING: TRAVEL TIME WILL INCREASE	NO COST SAVINGS CALC. TIME PERIODS -SHORT TERM 0-5 YEARS -MEDIUM TERM 5-15 YEARS -LONG TERM >15 YEARS
	CONGESTION DURING PEAK HOUR VOLUMES		MODERATE	MODERATE	MODERATE	MODERATE	MODERATE / BAD	MODERATE / BAD	MODERATE / BAD	MODERATE IN THE SHORT TERM	SEVERE WITH INCREASING DELAYS	
	RAT RUNNING—THE USE OF MINOR ROADS TO AVOID CONGESTION ALONG MAJOR ROUTES		*3 MINIMAL / MODERATE	*3 MINIMAL / MODERATE	*3 MINIMAL / MODERATE	*3 MINIMAL/MODERATE	MINIMAL	HIGH	*3 MINIMAL / MODERATE	MODERATE	HIGH	
			*3 CONCEPTS 1, 2, 3, 4 AND 7 MAY ALL INCREASE RAT-RUNNING IN THE NORTHERN AREAS OF PARKMORE BY PROVIDING ACCESS FOR MORE VEHICLES ALONG KELVIN DRIVE AND FELLAN ROAD									
	TRAFFIC DELAYS DURING CONSTRUCTION		MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	BAD	MODERATE	SEVERE	NO EFFECT	
BUSES AND TAXIS	IMPROVEMENT OF EXISTING PASSENGER ROUTES		LITTLE EFFECT	LITTLE EFFECT	LITTLE EFFECT	LITTLE EFFECT	MUCH IMPROVED	NO EFFECT	LITTLE EFFECT	MUCH IMPROVED	NO EFFECT	
PEDESTRIANS												

GROUP 2: OCCUPIERS

SUB GROUP	EFFECT	UNIT	CONCEPT 1 SRE ROUTE 1	CONCEPT 2 SRE ROUTE 2	CONCEPT 3 SRE ROUTE 3	CONCEPT 4 SRE ROUTE 4	CONCEPT 5 Republic Rd -Sandton Dr.	CONCEPT 6 Upgrading Ballyclare Dr	CONCEPT 7 Republic — SRE	CONCEPT 8 Selected Upgrading	NULL OPTION	COMMENTS
1. RESIDENTIAL	PROPERTIES EXPROPRIATED	NUMBER: VACANT OCCUPIED	10 14	19 14	25 13	10 27	>10 >20	<10	10 >29	NONE	NONE	
	PROPERTIES FRONTING ROUTE (NOISE EFFECTS)	NUMBER: VACANT OCCUPIED	40 30	40 57	40 60	54 53	16 36	>90	>40 35		NONE	
	PROPERTIES 50 — 100 m FROM THE ROAD	NUMBER: VACANT OCCUPIED	33 55	44 65	61 47	43 60	9 65	>50	>33 45		NONE	
	VISUAL OBSTRUCTION	NUMBER	SEVERE 8	SEVERE 18	SEVERE 50	SEVERE 55	SEVERE 19	SIGNIFICANT FOR ALL HOUSES FRONTING ONTO BALLYCLARE DR	SEVERE 30	FLYOVERS MAY BE VISUAL OBSTRUCTION TO HOUSES CLOSE BY	NONE	
	SEVERANCE		SEVERANCE BETWEEN RIVER CLUB EXT. 12 & 3	AS WITH CONCEPT 1 PLUS SEVERANCE ALONG PETER PLACE (BRYANSTON EXT 13)	SEVERANCE BETWEEN BRYANSTON EXT. 13 AND 14	SEVERANCE OF BRYANSTON EXT. 13 ALONG PETER PLACE	VERY SIGNIFICANT SEVERANCE	NEGLIGIBLE EFFECT	SIGNIFICANT SEVERANCE OF SANDHURST EXT. 4 AND RIVER CLUB 3	NO EFFECT	NONE	
	DISRUPTION DURING CONSTRUCTION		MODERATE	0	SLIGHT	SLIGHT	MODERATE	SEVERE	MODERATE	SLIGHT	NIL	
2. COMMERCIAL AND BUSINESS PREMISES	NOISE EFFECT ADJACENT TO NEW RD.	NUMBER: WITHIN 300m OF CENTER LINE	0	0	0	0	0	2	0	0	0	
	VISUAL OBSTRUCTION		NIL	NIL	NIL	NIL	NIL	SLIGHT FOR OFFICES	NIL	NIL	NIL	
	SEVERANCE		NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NIL	
	DISRUPTION DURING CONSTRUCTION		NIL	NIL	NIL	NIL	NIL	SLIGHT	NIL	NIL	NIL	
3. SCHOOLS AND HOSP. a) BRYANEVEN PRIMARY	SAFETY		NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	INCREASED SAFETY PROBL. FOR CHILDREN	NO EFFECT	NO EFFECT	NIL	
	INCREASED NOISE IN CLASSROOMS		NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	SIGNIFICANT INC. IN NOISE LEVEL	NO EFFECT	NO EFFECT	NIL	
b) MORNINGSIDE CLINIC	NOISE INCREASE	NUMBER: WITHIN 300m OF CENTER LINE	YES	YES	YES	YES	YES	YES, IF MORNINGSIDE OPTION IS TAKEN	YES	NO EFFECT	NO	SEE MAP FOR MORNINGSIDE OPTION
	VISUAL OBSTRUCTION		MODERATE	MODERATE	MODERATE	MODERATE	MODERATE	SLIGHT, WITH MORNINGSIDE OPTION	MODERATE	NIL	NIL	
	DISRUPTION DURING CONSTRUCTION		SLIGHT	SLIGHT	SLIGHT	SLIGHT	SLIGHT	DITTO	SLIGHT	NO EFFECT	NO EFFECT	

FIGURE 6.2 Example of Framework Presentation

Members of the evaluation panel received a general briefing document and were then taken on a site visit accompanied by members of the study team and various experts to answer their questions. Panelists were given forms on which to record potential impacts as they walked the route. After the site visit, lunch was served and then the panelists undertook the first iteration of impact identification. This involved listing (on separate, colour-coded forms) the costs and benefits of each of the final proposals and, where appropriate, specifying what group or groups would bear the cost or receive the benefit. The panelists worked silently and independently, but in the same room, to encourage concentration on this important task. When the panelists had completed and submitted the unsigned forms, the meeting was adjourned.

The project coordinator and an assistant then synthesized and refined the impact lists, incorporating any costs and benefits identified by the public and the authorities that were not listed by any members of the panel. Since it was discovered that all three of the final proposals would have the same types of impacts, differing only in degree, it was possible to prepare one list of costs and one list of benefits to guide the assessment and evaluation process.

Copies of the two synthesized lists were then sent to each panelist for review and comment to ensure that all potential impacts had been identified, and that the definitions given accurately reflected the perceptions of the panel. Some changes in wording were suggested, and one new benefit was identified, and these suggestions were incorporated and returned to the panelists for approval. A few minor modifications were subsequently required before the panel reached consensus that both the costs and the benefits of the final proposals had been comprehensively and accurately described, and this iteration was accomplished by telephone. (The final listing of costs and benefits is presented in Appendix JJ).

The impact lists were used to guide further investigations needed to prepare an impact report. This report - called the Delphi Briefing Document - was to assist the panelists in evaluating the relative significance of the costs and benefits, and in applying the specified evaluation criteria to the three final proposals. The 49-page document was arranged in two parts. Part One presented general information under the following headings:

- Purpose of this Report
- Description of the Situation
- Description of the Three Routes
- Description of the Affected Environment
- Description of the Affected Groups

Part Two presented specific information describing, for each of the benefits and costs that had been identified, how the three routes would compare. Each benefit and cost was discussed in turn using the following format:

- Identification of Affected Group
- Description of Impact
- Magnitude of Impact
- Mitigation Measures (if appropriate).

Appendix KK presents excerpts from the Delphi Briefing Document to illustrate how these benefits and costs were presented.

A draft of the Delphi Briefing Document was sent to a number of advisors with special knowledge of key aspects of the material covered to verify that the report was complete and accurate, and the report was modified as required before it was sent to the Delphi panelists.

The final Delphi Briefing Document was then sent to the panelists, along with one set of rating forms. Panelists were asked to rate the costs and benefits associated with each route before coming to the meeting. This would ensure that panelists had carefully studied the document, and given considerable thought to the relative significance of the impacts for each route. In addition, it would save considerable time in the meeting to have already accomplished one iteration of rating.

In addition, because of the great complexity of undertaking a comparative evaluation of a large number of costs and benefits for each of three routes, and the amount of time that would be required to do so, it was decided to depart from the standard evaluation procedure in this meeting. Rather than immediately undertake two more iterations of rating the impacts for each of three routes, the panel would first rate how well each route met each of the three evaluation criteria, and vote on which route was superiour in terms of all the criteria taken together. This would make it possible to eliminate one of the routes, and possibly two, before applying the rigorous and time-consuming evaluation that would be required to determine the relative significance of the costs and benefits. For example, if a large majority of the panel felt that one of the routes was clearly superiour to the other two in terms of the three evaluation criteria, then only the impacts associated with this one route would have to be evaluated in order to determine whether the costs outweighed the benefits or vice versa.

The Delphi meeting was convened on 16 August in a conference room in the Sandton Civic Centre. For the reasons given above, the normal procedure was altered, and a variation of the Criteria Trade-off Technique was undertaken first. Panelists were asked to apply the evaluation criteria by rating the three routes, using a scale from 1 to 7, as to how well each satisfied the three evaluation criteria: efficiency, equity and sustainability. Three iterations of rating were done, with feedback in the form of histograms after each iteration. Figure 6.3 presents the results of the final iteration. It can be seen that none of the panelists thought that Routes 3 or 4 satisfied any of the evaluation criteria particularly well, whereas the majority of the panelists judged Route 2 to be moderately successful in terms of all three criteria.

After the rating procedure was completed each panelist was asked to complete a modified version of the personal evaluation statement (see Application of Selection Criteria in Chapter 5). This involved filling in a form which directed the panelist through a series of comparisons and decisions concerning which route best satisfied each criterion separately, and all three criteria taken together (see Box 6.1).

Since a large majority of the panelists (10 of 13) felt that Route 2 was the best of the three alignments within the South Road corridor, it was not considered necessary to further evaluate the costs and benefits associated with Routes 3 and 4. Although the terms of the brief had specified that the study would be directed at identifying which of the South Road alignments would be in the best interests of the people who live and work in Sandton, it was also requested that the selected route be compared to the null option.

There was, therefore, still the question as to whether Route 2 was better than the null option: a more refined measure of the relative significance of Route 2's costs and benefits was needed before this question could be answered with confidence. The approach taken to addressing this aspect of the evaluation was to ask the panel to use the Significance Measurement Technique to judge the relative significance of the costs and benefits associated with Route 2 in order to determine whether this route would have a net benefit.

```
EFFICIENCY :

Route 2          Route 3              Route 4

7                7                    7
6 ******         6                    6
5 **             5                    5
4 ****           4 **                 4
3 *              3 ********           3 **********
2                2 ***                2 ***
1                1                    1
```

```
EQUITY :

Route 2          Route 3              Route 4

7                7                    7
6 *              6                    6
5 *              5                    5
4 *******        4                    4 *****
3 **             3 **********         3 *****
2 **             2 ***                2 ***
1                1                    1
```

```
LONG-TERM CONSEQUENCES :

Route 2          Route 3              Route 4

7                7                    7
6 ******         6                    6
5 **             5                    5
4                4 *******            4 *
3 **             3                    3 ***
2 *              2 ******             2 *********
1 **             1                    1
```

FIGURE 6.3 **Results of the Final Iteration of Criteria Rating**

As mentioned earlier, the panelists had already accomplished, before coming to the Delphi meeting, one iteration of rating the costs and benefits of all three routes. After computer-generated histograms of the results for Route 2 were presented to the panel, panelists accomplished a second iteration of rating the costs and benefits of Route 2. After the results of the second iteration were given to the panel, each panelist undertook a final iteration of rating and used this final rating to rank-order the items on each list.[5]

Having achieved a personal ranking of costs and a ranking of benefits, each panelist then applied the weighting (or ratio-scoring) procedure to determine the relative significance of each item on the respective lists. This procedure involves assigning the number "10" to the 'threshold impact" - *i.e.*, the first impact that crosses the threshold of significance (see Impact Evaluation in Chapter 5).

5 Because of time constraints it was not possible to accomplish a third iteration with feedback before the ratio-scoring procedure was undertaken.

BOX 6.1
Form for Identifying Preferred Route

Ranking routes according to: Efficiency	Ranking routes according to: Equity	Ranking routes according to: Long-term consequences
Route __ ranks 1st	Route __ ranks 1st	Route __ ranks 1st

Evaluation Procedure:

1. Should the most efficient Route be rejected because of its unfavourable distributional consequences?

   YES __ NO __
   (If Yes, go to 3 - if No, go to 2)

2. Should the most efficient Route be rejected because of its unfavourable long-term consequences?

   YES __ NO __
   (If Yes, go to 3 - if No, go to 4)

3. Should the most equitable Route be rejected because of its unfavourable long-term consequences?

   YES __ NO __
   (If Yes, go to 5 - if No, go to 6

4. The preferred Route is the one which is most efficient:

   Route _____

5. The preferred Route is the one with the most favourable long-term consequences:

   Route _____

6. The preferred Route is the one which is most equitable:

   Route _____

THE BEST ROUTE OVERALL IS ROUTE : ______

In order to ascertain whether the threshold impacts on the two lists were of equivalent value, panelists were asked to compare the first cost to receive a weighting of "10" with the first benefit to do so, and then to indicate whether one was more significant than the other. This was to be done by assigning a number to the more significant one that would indicate its ratio of importance to the one of lesser importance. The intention was to adjust impact weights on one list if necessary, but if it was found that there was no significant difference in the ratio of importance of the threshold impacts, then it would be possible to directly aggregate the weightings given the costs and benefits, and so determine whether the costs of Route 2 outweighed the benefits.

The Results

The results of the comparative evaluation between the three routes for the South Road corridor were as follows:

- all thirteen panelists judged Route 2 to be the most efficient;
- ten panelists judged Route 2 to be the most equitable;
- ten panelists judged Route 2 to have the best long-term consequences; and

- ten panelists selected Route 2 as the best route overall.

The results of the comparative evaluation between the preferred route for the South Road corridor - Route 2 - and the null option were that the costs of Route 2 were judged to outweigh the benefits by a ratio of approximately 3 : 2 (see Figure 6.4). Eleven out of the thirteen panelists judged that the costs of Route 2 outweighed the benefits. Table 6.13 presents the ratio of costs to benefits derived from each panelist's weightings. Table 6.14 provides the overall ranking of costs and benefits and their associated mean importance scores.

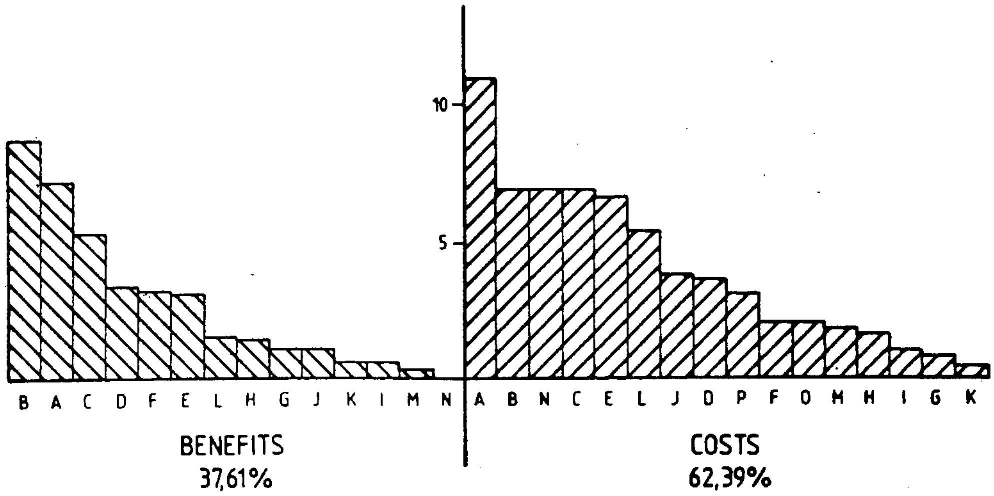

FIGURE 6.4 Ratio of Costs to Benefits for Route 2

The two major conclusions of the study were that Route 2 was the best of the three South Road Extension proposals, but the costs of this route still exceeded its benefits by a substantial margin. The two major recommendations of the study were that none of the South Road Extension proposals should be constructed, and that Sandton Town Council should reconsider one or more of the upgrading options that would satisfy short- and medium-term needs.

TABLE 6.13

Ratio of Costs to Benefits Calculated for Each Panelist

Panelists	1	2	3	4	5	6	7	8	9	10	11	12	13
Costs	83	89	60	64	51	68	63	43	67	57	31	52	82
Benefits	17	11	40	36	49	32	37	57	33	43	69	48	18
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

Assessment of the Evaluation

As in all the case studies, the brief had to be amended to ensure that the evaluation would be relevant. There was considerable reluctance on the part of certain members of the steering committee to allow consideration of the null alternative (or any other alternatives), but members of the research team insisted that in view of the degree of public opposition, and to conform with accepted principles of environmental assessment and evaluation, it was necessary to consider the null alternative, as well as other major alternatives put forward by opponents to the South Road Extension proposals.

TABLE 6.14
Ranking of Costs and Benefits

RANK ORDER OF BENEFITS		RANK ORDER OF COSTS		RANK ORDER OF COSTS AND BENEFITS		
B	8,74	A	11,29	COST	A	11,29
A	7,33	B	6,68	BENEFIT	B	8,74
C	4,49	C	6,61	BENEFIT	A	7,33
D	3,50	N	6,61	COST	B	6,68
F	3,38	E	6,23	COST	N	6,61
E	3,31	L	5,52	COST	C	6,61
L	1,55	J	3,82	COST	E	6,23
H	1,49	D	3,69	COST	L	5,52
G	1,13	P	2,54	BENEFIT	C	4,49
J	1,11	F	1,97	COST	J	3,82
K	0,65	O	1,83	COST	D	3,69
I	0,61	M	1,80	BENEFIT	D	3,50
M	0,33	H	1,66	BENEFIT	F	3,38
N	0,00	I	0,91	BENEFIT	E	3,31
		G	0,83	COST	P	2,54
		K	0,38	COST	F	1,97
				COST	O	1,83
				COST	M	1,80
				COST	H	1,66
				BENEFIT	L	1,55
				BENEFIT	H	1,49
				BENEFIT	G	1,13
				BENEFIT	J	1,11
				COST	I	0,91
				COST	G	0,83
				BENEFIT	K	0,65
				BENEFIT	I	0,61
				COST	K	0,38
				BENEFIT	M	0,33
				BENEFIT	N	0,00

DESCRIPTION OF BENEFITS:

A Improved Mobility within Sandton
B Peak Hour Congestion Reduced
C Improved Regional Links
D Reduced Vehicle Costs
E Improved Road Safety
F Improved Quality of Environment along Existing Neighbourhood Roads
G Reduced Road Maintenance Costs
H Increased Growth and Prosperity
I Potential for Development at Golf Club Site
J Increased Job Opportunities
K Additional Servitudes
L Improvement of Braamfontein River Trail
M Improvement of River Club Spruit
N Improved Coherence of Urban Landscape

DESCRIPTION OF COSTS

A Reduced Value of Sandton Field and Study Centre
B Reduced Value of Braamfontein Spruit Trail
C Increased Pollution Impacts in Certain Neighbourhoods
D Reduced Property Values
E Change in Community Character, Cohesion and Safety
F Inconveniences During Construction
G Reduced Amenity Value of the River Club Golf Course
H Potential Loss of Open Space
I Effect on Morningside Clinic
J Loss of Property and Development Rights
K Reduced Housing Stock
L Financial Costs
M Effects on River Club Spruit
N Decrease in Overall Quality of Environment Beyond the Immediate Environs of the Road
O Reduced Incentive to Improve Public Transport Facilities
P Confidence in Local Authorities Threatened

Nevertheless, the brief that was eventually agreed upon greatly restricted the scope of the study since the focus was on applying evaluation criteria to the South Road Extension proposals. One of the stipulations in the brief was that only those alternatives which were capable of satisfying certain conditions - such as the ability to meet long-term traffic needs - could be selected as final proposals for a detailed evaluation. This meant that many alternatives to the South Road Extension proposals (some of which were widely supported by certain sectors of the public), received a relatively perfunctory evaluation through the Framework Approach.

In addition, because most of the evaluation effort went into determining the best alternative alignment within the South Road corridor, the null alternative was never properly evaluated (or even directly compared to any of the final proposals). This was not completely satisfying to members of the panel or the study team; since the evaluation criteria were not applied to the null alternative, it was not possible to state conclusively that the null alternative was better than Route 2, but only that the costs of Route 2 outweighed the benefits of Route 2.

Another limitation of the conditions imposed by the brief was the stipulation that the alternative proposals were to be evaluated from the point of view of those living and working in Sandton. This meant that the regional benefits of the road were not to be explicitly considered. In addition, the study team was instructed to assume that Sandton residents would bear the entire monetary costs of the road, when in fact there was a reasonable prospect that the provincial government would subsidize the road because of its potential to serve as a major link in a regional network.

Other general problems concerned the availability and reliability of forecasts pertaining to traffic congestion and safety, and disputes over the accuracy of some data. Because of severe time constraints imposed on the study by Sandton Town Council, insufficient time was provided for review of the draft Delphi Briefing Document. This meant that only a few people were given the opportunity to comment on the draft report, and these people had little time to check data and offer better figures.

In spite of time and data limitations, the Panel Evaluation Method worked well and both the panel and the study team felt satisfied with the techniques employed. The Impact Identification Technique produced a comprehensive list of precisely-defined impacts, which was essential to further assessment and evaluation; the Criteria Trade-off Technique made it possible to systematically and explicitly select the option which best met the evaluation criteria; and the Significance Measurement Technique provided a clear indication that - given the assumptions specified in the brief - the costs of the best alignment within the South Road corridor outweighed its benefits by a considerable margin.

There were problems with the computer during the Delphi meeting, but it was possible to keep the panel occupied on other relevant tasks while the problem was resolved. The panel had no difficulty in applying the evaluation criteria to identify the most promising proposal before judging the relative significance of impacts associated with that proposal. This saved considerable time, and probably the necessity for a second meeting.

In addition, the panelists were able to complete a rating of six lists of impacts (a list of costs and a list of benefits for each of three alternatives) before coming to the Delphi meeting. This also saved time in the meeting, and gave the panelists a better feel for the relative significance of the impacts so that they could do a better job of applying the evaluation criteria. Some of the panelists also remarked that the necessity of rating the impacts immediately after reading the Delphi Briefing Document encouraged a closer reading of the document, and reinforced their understanding of the material.

The panelists seemed to have no difficulty in understanding or applying the ratio-scoring procedure, and all indicated that the procedure helped to clarify their feelings about the relative merits of the proposal. Even those panelists who felt that Route 2 had net benefits said they could see why the others might feel otherwise, and were willing to accept the group judgment. This finding indicates that individuals may be more inclined to recognize and accept differences of opinion if a rigorous procedure such as the Panel Evaluation Method is employed.

Finally, ten of the thirteen panelists were satisfied that the threshold impacts for each of the two lists were of equivalent significance. Of the three panelists who felt that the significance of these impacts were not equivalent, the ratios of costs to benefits were 10 : 15; 10 : 30; and 20 : 10. These differences in the subjective point of origin would not significantly affect the group weightings. This finding indicates that the threshold of significance concept provides an effectively common point of origin for scaling positive and negative outcomes, so that weightings can be aggregated to determine whether costs exceed benefits.

DISCUSSION

This chapter has presented the results of three case studies in which the Panel Evaluation Method was modified to meet special circumstances, or to test new analytical procedures. In some cases other methods and techniques, such as the contingent valuation survey technique and the Krutilla technique (see Case Study 4, The Study, and Appendix L) were adapted and integrated into the study design to assist in the accomplishment of one or more of the nine tasks that have been prescribed for conducting a formal evaluation.

Of special interest was the opportunity to apply the Panel Evaluation Method to very different types of resource allocation problems to assess the adaptability and cost-effectiveness of the method. The method was found to be applicable and easily employed in all cases, and was generally considered by participants to be helpful and appropriate, particularly in accomplishing the difficult tasks of defining potential impacts and judging their relative significance.

Two variations of the Impact Identification Technique were developed and successfully applied in different case studies. In Case Study 5, impacts were identified in two meetings on successive days (rather than through the post), but using Delphi concepts (rather than the Nominal Group Technique as in Case Study 2). In Case Study 6, the first iteration of impact identification and definition was done in a meeting situation, and subsequent iterations were conducted by post and telephone. Both approaches produced positive results, and significantly shortened the time required to develop a satisfactory list of impacts.

In Case Study 5, substantial evidence was obtained that the Impact Identification Technique is not only reliable, but produces a more comprehensive and clearly-articulated list of impacts than is likely to be produced by a single analyst. Furthermore, the evidence indicates that the project coordinator does not bias or distort the panel's judgment in identifying, defining and scoring impacts, but does act as a catalyst in crystalizing the panel's thinking and improving impact definitions. This important result is apparently achieved through a nonbiasing interaction of the project coordinator with the panel in interpreting impacts over two or more iterations. The project coordinator thus appears to play a crucial facilitating role which ensures that

- the list of impacts is comprehensive (so that all matters of potential concern to anyone are identified),
- the impacts are truly independent (to avoid double counting), and
- sufficient attention is given to refining impact definitions (so that the nature of the impacts will be more readily communicated and accurately interpreted).

Two of the case studies have provided further evidence that the technique for evaluating the relative significance of impacts is capable of producing replicable results (see Case Study 4 and Case Study 5). Of particular note was the consistently high correlations that were obtained in Case Study 4, for which comparisons were made of the scores given to 92 pairs of identical lists of impacts by various combinations of nine panels. These comparisons yielded a correlation coefficient of 0,8 or better in 80% of the cases, and 0,7 percent or better in 93% of the cases.

In addition, all nine panels essentially agreed on the ratio of total benefits associated alternative proposals. This indicates that the threshold impacts on all lists of benefits were of approximately the same value and thus effectively served as a common point of origin for scaling subjective value judgments.

Evidence was also obtained in Case Study 6 that it is valid to combine panel weightings (scores) given to the costs of a proposal with those for its benefits to determine whether the net benefit of that proposal is positive or negative. This indicates that the threshold of significance concept is a legitimate and practical concept for aggregating individual value judgments concerning both positive and negative outcomes to arrive directly at a group determination as to whether a proposal is efficient. This obviates the need to calculate and analyze fractional contingency prices, which may be insufficiently precise to warrant the analytical effort or to achieve general acceptability. In addition, fractional contingency prices are dependent on calculations of present discounted value, and so may be impractical in many Third World situations.

While further research should be done to corroborate these results, Case Studies 3-6 provide substantial evidence that the hypothesis set out in Chapter 5 (see Impact Evaluation in Chapter 5) can be confirmed: it seems that two panels will make essentially the same judgments concerning the relative significance of impacts provided that certain conditions are met. Due to resource limitations it was not possible to establish precisely what conditions are both necessary and sufficient to bring about this result, or to what degree any of the postulated conditions must be met. It is of some interest, however, that though several of the postulated conditions varied considerably in Case Study 4, these differences (pertaining to both procedures and the composition of the panels) did not appear to greatly affect the reliability of the Significance Measurement Technique. This indicates that many of these variables may not be so critical in assuring that a panel's judgments will be very similar to another panel's judgments, and so constitute an acceptable appraisal of the efficiency of a proposal.

In conclusion, these case studies have demonstrated that the Panel Evaluation Method provides a sound analytical approach to assist decision makers in making difficult choices between fundamentally different resource allocation proposals which are highly controversial.

CHAPTER 7
SUMMARY, DISCUSSION AND CONCLUSION

SUMMARY OF RESEARCH OBJECTIVES AND RESULTS

This study has been concerned with the general problem of improving resource allocation decisions, with particular reference to South Africa. There are many facets to this problem, and therefore this dissertation has addressed a wide range of questions pertaining to resource evaluation and management. A general philosophical framework to guide resource allocation decisions has been developed, as well as a number of specific techniques for accomplishing evaluations. While these techniques can be used to evaluate any resource allocation proposal, the research focus was on the problem of how to decide which of two controversial and mutually-exclusive resource allocation proposals would be in the best overall interests of society.

A major motivating factor for this study was the challenge which was identified by the framers of the National Environmental Policy Act of 1969 in the United States. This was to identify and develop methods and procedures for evaluating the effects of proposals "which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical considerations" (United States, 1969:Sec.102[2][B]).

The study began with investigations into the question: "How can the value of unpriced environmental services be measured and compared with that of priced goods so that rational judgments may be made about the total social value of a proposal?" Most of the research effort in this study was directed at developing and testing a reliable scaling technique that would allow the significance of all outcomes of a proposal to be judged and measured on an interval scale. But the study broadened as it became apparent that the development of a scaling technique would not in itself provide a satisfactory solution to the real problem implied by the question. In addition to the scaling technique, there was a need to provide more general evaluation and decision making procedures within which such a technique could be employed.

Accordingly, the first objective of the study was to develop a suitable philosophical framework of evaluation and management that would include a rational strategy of resource management, but that would emphasize a practical research methodology for environmental evaluation to guide and support that strategy. The approach taken to formulating the philosophical framework was to define a specific form of the social welfare function, and to identify a general goal and specific objectives for resource allocation with which most people could agree. Care was taken, therefor, to base the goal and objectives on premises that are relatively uncontroversial. The reasoning was that if contending parties can agree that the principles and concepts underpinning the management strategy and evaluation methodology are rational and valid, then greater acceptance can be expected both of the evaluation procedures to be used and the decisions that will ultimately be taken.

The environmental evaluation methodology itself is based on a satisficing model, but incorporates an optimizing model to be applied when choices are especially controversial. This might be regarded as a type of "mixed scanning" or synthesis approach (Janis and Mann, 1977) which involves searching for reasonable solutions in the early stages of evaluation, and then using more formal techniques for analyzing preferences if no solution is found that would be relatively uncontroversial. The criterion that is used to decide whether to satisfice or optimize, and whether to employ informal or formal evaluation techniques, is thus the level of <u>controversy</u> that attends a proposal. This is believed to be an original approach to resolving the quandary of whether to satisfice or optimize in resource allocation evaluation and decision making.

The second objective of the study was to develop a formal method of evaluation to be applied to those resource allocation proposals which are especially controversial. This led to the development of techniques that could be used to identify the expected outcomes of a proposal, compare their relative significance, and determine whether the proposal (or some alternative) should be approved. The evaluation procedure that eventually resulted - the Panel Evaluation Method - is directed at obtaining group judgments as to both the identity and relative significance of outcomes associated with competing proposals, and the extent to which they meet specified evaluation criteria.

The Panel Evaluation Method is based on the so-called "Delphi Method", pioneered by the Rand Corporation in the United States (Pill, 1971). The evaluation procedures which comprise the Panel Evaluation Method are intended to ensure that the evaluation process is comprehensive, systematic and explicit. This formal method of evaluation, which is directed at determining the most optimal solution to a controversial resource allocation problem, is based on a heuristic search procedure so that a simple and limited analytical device can be used to make complex decisions and solve difficult problems when limited resources are available and the decision making environment is relatively unsophisticated. The idea is to be selective and cost-effective without losing relevance and credibility, and to provide solutions that have operational significance and are acceptable. Thus the major concern is to develop credible problem formulation, scaling and trade-off procedures for handling complex, qualitative data.

Einhorn and Hogarth (1981) state that one must design procedures that are within the capabilities of the organism and are functional in dynamic environments. Simon (1978) says that we are creatures of "bounded [or limited] rationality", and so we resort to gross simplifications when dealing with complex decision problems. This suggests that the essential task of an evaluation method is to structure the choice situation in a way that seems helpful and that will reduce the arbitrariness of judgments. Because of our limited ability to foresee consequences or obtain information about alternative choices, and because heuristics appears to work well in complex environments, human responses may be more appropriate than optimal models in guiding choice. The problem with resolving value conflicts at the level of decision rules, rather than at the level of individual decisions within the framework of a specific and unique situation, is that importance weights cannot be assigned out of context. The Panel Evaluation Method stresses content over structure (*i.e.*, the model is context specific), and emphasizes connections with the real world and the meaning of choices in a particular framework.

The third objective of the study was to apply the formal evaluation method and provide empirical evidence for assessing the efficacy of this method. This involved considerable field work that was accomplished over a period of several years. Two approaches for formally evaluating controversial resource allocation proposals were applied to a total of six South African case studies. Both approaches feature group evaluation procedures based on Delphi concepts of anonymous debate, controlled feedback, and statistical displays of group response. When the first approach was applied to two case studies, several difficulties were encountered, and it was necessary to develop more effective and acceptable procedures for identifying and defining impacts, measuring the relative significance of impacts, and trading-off evaluation criteria. The second approach - the Panel Evaluation Method - features three techniques which were designed to resolve these difficulties:

- The Impact Identification Technique provides a mechanism for ensuring that all impacts of possible significance are identified and clearly defined.

- The Significance Measurement Technique is designed to produce a reasonably reliable estimate of the relative value of impacts associated with each alternative evaluated.

- The Criteria Trade-off Technique can be used to apply the three evaluation criteria - efficiency, equity and sustainability - and make trade-offs when no alternative is superior in terms of all three criteria.

These techniques were tested in four case studies to judge their general usefulness and acceptability. Emphasis was on assessing the reliability of the Significance Measurement Technique, since it concerned the principal topic of interest in this study: the challenge of determining the value of nonmonetizable impacts. Reliability was assessed by constituting several panels to conduct parallel evaluations of identical lists of impacts, and then calculating the product-moment correlation coefficient for the weightings given these impacts by the respective panels. It was found that the procedures and techniques were useful and produced replicable results, and could be modified to meet different circumstances.

The next section presents a more detailed discussion of the major findings and conclusions of this study.

DISCUSSION OF RESULTS

This study has resulted in the development of a philosophy of resource evaluation and management which is based on a clearly-articulated goal and objectives. This philosophy encompasses a resource management strategy and an evaluation methodology to aid decision making. The management strategy features a national conservation policy, principles governing legislative initiatives, and a general administrative procedure for processing resource development applications. The evaluation methodology includes both quantitative and qualitative techniques for applying specified evaluation criteria, and features a formal method for evaluating especially controversial resource allocation proposals.

This section presents the major conclusions of the study, discusses the extent to which the research objectives have been met, and highlights those aspects of the findings which may be regarded as constituting an original contribution to knowledge.

The Philosophical Framework

The philosophical framework for guiding resource allocation decisions was found to have appeal to virtually all of the participants in the study. No objections were raised concerning the acceptability of the premises used to define the goal of resource allocation, nor was there any disagreement as to the declared objectives of resource allocation, and to the validity of the evaluation criteria that should be applied to resource allocation proposals.

None of the aspects of the philosophical framework were formally tested or judged in any way; while this would have been desirable, it was not thought to be essential to accomplishing the principal research objectives: the development and assessment of a formal method for evaluating controversial resource allocation proposals. Nevertheless, much support was found in the literature for the principal ideas that are presented here.

The Social Welfare Function

A special feature of the philosophical framework is a proposed modification of the social welfare function in economic theory. This proposal, to modify the social welfare function by incorporating the concept of sustainability, is similar to a proposal by Herfindahl and Kneese (1974:386-397) but was independently derived. It is believed that this suggestion may constitute a modest contribution to the theoretical development of environmental economics and point the way to more sophisticated elaborations of the social welfare function and more relevant methods for evaluating resource allocation proposals. It is also believed that the Criteria Trade-off Technique represents a unique and practical approach to the problem of applying a special criterion concerning the possible effects of an action on future generations.

Although the addition of the sustainability criterion (also called the intergenerational criterion) to the social welfare function does complicate the "big trade-off" - heretofore limited to the efficiency criterion and the equity criterion (Okun, 1975) - this proposal seems justifiable in light of the new environmental circumstances facing mankind. Adoption of the sustainability criterion is in line with current thinking about the importance of sustainable development (Allen, 1980; Clark, 1989; International Union for the Conservation of Nature, 1980; World Commission on Environment and Development, 1987), and resolves a problem that has long concerned many conservationists: how to counteract the effect of discounting the future stream of costs and benefits (a standard procedure for determining efficiency), which creates a bias favouring present generations.

The Management Strategy

The management strategy presented in this dissertation is not fully developed as this was not the central topic of concern. The object was only to present the broad outlines of certain resource management issues that were considered especially relevant to developing a satisfactory philosophical framework for guiding resource allocation decisions. This general strategy would then provide the context for the application of a research methodology designed to apply evaluation criteria to specific proposals.

The adoption of a national conservation policy to constrain the decision making space for individual resource allocation decisions was particularly germane; such a policy would serve to avoid the dangers of cumulative and synergistic effects from decisions taken in isolation. Another important aspect of the management strategy was to state the principles which should be observed in formulating legislation governing resource allocation decisions. Finally, it was believed necessary to outline certain administrative procedures and practices within which an effective evaluation methodology could be applied, and which could in fact be regarded as part of the methodology itself.

The Evaluation Methodology

The central feature of the evaluation methodology presented in this dissertation is the attempt to link two general approaches which are commonly used to provide information needed to evaluate resource allocation proposals: Environmental Impact Assessment and Cost-benefit Analysis. This has been done by adopting a cost-benefit framework within which environmental and economic analyses of resource allocation proposals are integrated. This attempt to extend the power and utility of complementary disciplines by combining them into a general approach to environmental evaluation is believed to be original and successful.

The cost-benefit paradigm for both environmental assessment and resource decision making is intuitively appealing, and the idea of regarding all the outcomes of an action as either costs or benefits is widely accepted and practiced. The cost-benefit concept can be used to apply all three evaluation criteria:

- to apply the efficiency criterion, what is needed is to know whether benefits exceed costs (and if so by how much) for society as a whole;
- to apply the equity criterion the question pertains to the net benefit (or cost) that would fall to particular groups living in society today; and
- to apply the sustainability criterion, it is necessary to judge whether benefits will exceed costs for future generations.

The question as to who should make these judgments, and exactly how they should be done, depends largely on the degree of controversy that is anticipated and the importance of the decision. If the issue is not expected to be particularly controversial, informal methods conducted through the interaction of analysts and decision makers will suffice; otherwise, a formal evaluation is desired, and the evaluation will have more credibility if it is accomplished by a group of unbiased and respected persons, and if it employs procedures which are designed to integrate the knowledge and value judgments offered by these persons in an unemotional and rational way.

The information needed to apply the evaluation criteria can be supplied by environmental analyses done for an Environmental Impact Assessment, and by shadow-pricing techniques done as part of a Cost-benefit Analysis. The evaluation methodology developed in this dissertation makes provision for both formal and informal methods and techniques of evaluation, with varying degrees of sophistication. In a country which has relatively little experience with and resources for conducting full evaluations of resource allocation proposals, it seems reasonable to modify the conventional methods and techniques of evaluation that were developed in the First World so that they are easy and inexpensive to apply. Accordingly, relatively simple and unsophisticated variations of certain established techniques for estimating the value of unpriced effects were developed and applied in several of the case studies. The reasoning behind these adapted techniques, and the procedures used, seemed to be acceptable to the key figures for whom these studies were done, as well as to the participants in the studies.

If shadow pricing or other valuation techniques can be applied to unpriced impacts so as to estimate the net benefit for each of two competing proposals, then conventional Cost-benefit Analysis can be used to determine which proposal is more efficient . Although theoretically Cost-benefit Analysis could be applied to each group that would be differently affected, as well as to future generations, the high costs, lack of reliable data, and certain theoretical difficulties (particularly pertaining to intergenerational questions) would normally preclude a rigorous Cost-benefit Analysis for applying the equity and sustainability criteria. Therefore, it is more practical to rely on other evaluation procedures (such as the Criteria Trade-off Technique) for making judgments regarding equity and sustainability, as well as for determining which proposal best satisfies all three evaluation criteria.

Special attention was given in this study to the problem of making efficiency determinations. While shadow-pricing techniques can provide value information which greatly reduces the complexity of the analysis, and can sometimes resolve the value uncertainties, a special problem exists if there are a large number of completely nonmonetizable impacts. This is often the case with resource allocation proposals which are especially controversial. Because such cases are usually highly complex, and involve many environmental services which lie outside the normal realm of economic valuation, it is generally impossible to calculate shadow prices for many of the unpriced impacts. The challenge then is to adequately take account of the value or significance of these impacts, and to weigh their value against those other values that can be expressed in monetary terms.

The Formal Method of Evaluation

Most of the research effort in this study has been directed at developing and testing a method for evaluating controversial proposals which have a large number of nonmonetizable impacts. The Panel Evaluation Method was designed to accomplish nine tasks that were identified as being of special importance to such an evaluation; following is a discussion of the experience gained in four case studies in accomplishing these tasks.

Establishing the Terms of Reference

Great difficulties were experienced in simply determining what was wanted and what was possible. It is therefore concluded that it is of the utmost importance to spend considerable time clarifying the brief and exploring the possibilities of finding some compromise solution to the resource allocation conflict. Frequent and thorough consultations with key parties can help ensure that investigations are relevant, and that the evaluation procedures employed are appropriate and necessary.

Describing the Study Area

No particular problems were experienced in accomplishing this task. The challenge is to gather enough data to guide the evaluation process without wasting time and effort accumulating extraneous data that will only cloud the evaluation.

Identifying the Final Proposals

This remains a difficult task, and no special procedures were discovered that would greatly facilitate its accomplishment. What is needed is a commitment to consultation and negotiation, as well as considerable patience and ingenuity. Feedback on the acceptability of proposals is important, and therefore there should be some mechanism for effecting a dialogue (direct or indirect) between proponents and opponents of a proposal. What will normally be required is an iterative process of design, comment and re-design, which may continue beyond the proposal generation stage into the assessment stage. But it is important to have absolute clarity as to exactly what actions will be involved before the proposal is finally evaluated, including the mitigation or compromise measures that will be regarded as constituting an integral part of the proposal.

Selecting an Evaluation Panel

Although there are several important considerations in choosing the members of an evaluation panel - such as type of background and training, level of ability and knowledge, and motivational factors - perhaps the most important is that the panel will be respected by the principal parties involved in the controversy, particularly the decision makers. This means that individual panelists must be acceptable, and that the overall balance or composition of the panel seems reasonable (in terms of disciplinary orientation, professional affiliations and other characteristics which influence attitudes, opinions, values and general knowledge).

The chain-referral technique proved to be a generally-accepted means of obtaining a list of prospective panelists, but concern was sometimes expressed about allowing the project coordinator to initiate this process and then undertake the final selection. One solution is to send the initial letters to all key parties that can be identified with interests in the issue; another is to use clear, objective selection criteria, or some random selection process. Of greatest importance, however, is that the proponents of proposals, as well as the authorities who must make the final decision, have an opportunity to veto the selection of any panelist, and that this is done in a way that ensures full confidentiality.

Identifying and Defining the Impacts

The difficulty and vital importance of this task was greatly underestimated at the outset of this study. While impact identification and definition was initially seen as a straightforward and relatively simple task, in retrospect, the development of the Impact Identification Technique is seen as one of the major contributions made by this study to the field of environmental evaluation.

A common failing in environmental evaluation is that environmental analysts often overlook potential impacts, or else summarily dismiss those that are very complex (such as subtle or long-term impacts) or those that seem of no consequence to the analyst (such as impacts of special concern to different cultures or socioeconomic groups). In an attempt to rectify this common failing, early Environmental Impact Assessment techniques emphasized rather mechanical procedures (such as comprehensive checklists and matrices) to ensure that all potential impacts would be identified. But this had the subtle effect of diverting attention away from the need to precisely define and describe impacts, and to focus on what could be done about those impacts which were of major concern.

The result was often the production of impact reports which were encyclopaedic rather than analytic in nature (Lee, 1982), and which did not provide the kind of information that was really needed to aid evaluation and decision making. Typically these reports contained too much material on minor impacts (usually biophysical and intermediate impacts which were relatively straightforward and easy to analyze) and not enough material on major impacts (usually socioeconomic and end impacts which were relatively complex and difficult to analyze).

The problem begins with impact identification. Many practitioners believe that this simply involves using a matrix or some other technique to identify the potential interaction of project actions with environmental characteristics. But an impact has not been <u>truly identified</u> until it has been precisely defined. Every individual has a different perception of reality, and a different understanding of the implications of an action. Forecasting the actual effects of an action is notoriously difficult, but it is also surprisingly difficult to simply define a potential problem and communicate one's understanding of the problem to another person.

This is an exceedingly significant obstacle to environmental assessment and evaluation: if the impacts that are of concern to the affected publics are not fully identified and clearly articulated, investigations may be irrelevant and the evaluation may be judged specious. The contending parties will then not be satisfied, and the decision maker will lack the information he needs to determine which proposal is in the overall best interests of society.

Related to this problem is the fact that the potentially affected publics on the one hand, and those who are charged with evaluation on the other, often do not work in concert in accomplishing this task. In fact, the affected publics are often not given adequate opportunity to voice their concerns; or if they are, these concerns may well be misinterpreted by those who undertake to evaluate these concerns. Therefore, it is important that an iterative procedure involving both groups simultaneously is employed, and that impact definitions are refined until all parties are satisfied.

The Impact Identification Technique ensures that the list of impacts will be comprehensive and fully relevant, so that all matters of concern or potential significance to anyone will be identified, defined, assessed and evaluated. This will improve the credibility and acceptability of the environmental evaluation process.

Another aspect of impact identification that is of crucial importance to the evaluation process is to ensure that all impacts are expressed in a way that clearly indicates their ultimate effect on social well-being; in addition, it is important that each impact is independent in its effect. Commonly the initial list of impacts that is generated will contain many impacts that are ambiguously worded, or that concern some effect not directly related to social well-being; in addition, some of the impacts often interact or overlap in some way, giving rise to double counting. Finally, the list of impacts will generally be too long and unwieldy (as well as too confusing) to be effectively evaluated.

The procedure for synthesizing impact definitions, and arranging impacts in a hierarchical structure, is a particularly important innovation of the Panel Evaluation Method. This procedure, in which "subimpacts" (intermediate impacts, or interacting/overlapping impacts) are grouped under crisply defined "impacts" (end impacts, which are independent in their effect), facilitates the evaluation process by reducing the number of impacts to be evaluated and, more importantly, by ensuring that the evaluation is theoretically sound, and that everyone is clear about what is actually being evaluated.

In Case Study 4, the various iterations of Impact Identification Technique were accomplished through the post. While this was satisfactory, it did take considerable time. In Case Studies 5 and 6, the technique was modified to allow some or all of the iterations to be accomplished in a meeting situation. These variations in the procedure were successful, and made it possible to obtain the final lists in a much shorter time.

In Case Study 5, an investigation was initiated into the question as to whether two panels would produce essentially the same list of impacts, and whether the project coordinator might influence impact identification and definition. The results indicate that the Impact Identification Technique is capable of producing replicable results, and that the project coordinator does not bias the panel's thinking. On the contrary, the iterative nature of the procedure, and the assistance of the project coordinator in re-organizing and re-defining impacts, appears to stimulate, clarify and enhance panel thinking so that better impact definitions are obtained.

Preferences depend on a how a decision problem is framed, and this dependency is a significant concern for the theory of rational choice (Tversky and Kahneman, 1981). It is hard to overemphasize the importance of framing the problem as clearly and accurately as is humanly possible. One must live with cognitive limitations, and accept that one can get reversals of preferences if problems are framed differently. The challenge is to frame problems in such a way that the cognitive environment will enable a meaningful, unambiguous and acceptable interpretation of acts, outcomes and contingencies or conditional probabilities. One of the major conclusions of this study is that an iterative approach to impact identification and definition, guided by a sensitive project coordinator, can vastly improve the way in which impacts are phrased and organized, and the way in which the resource allocation problem is framed; and this enhanced clarity will in turn greatly improve and increase the relevance of the assessment and evaluation process which is to follow.

Investigating the Impacts

This aspect of the environmental evaluation process did not receive major attention in this study. The literature is replete with methods and techniques of environmental assessment, and a number of useful procedures are available. Due to resource limitations, relatively perfunctory investigations were sometimes done to supply information to the evaluation panels in the case studies, and it was often necessary to rely heavily on secondary data. In some cases, adequate information was available and panelists felt confident in making subjective value judgments about the significance of the impacts and the extent to which proposals met the evaluation criteria. In other cases, however, panelists complained that they lacked information on which to base their evaluations, and there is no doubt that a thorough environmental assessment is essential to undertaking a sound evaluation.

Nevertheless, it is also true that one can overload panelists with data, and so it is important that impact reports are concise and well-structured. Accordingly, emphasis was placed on developing a report presentation that would communicate the salient findings in a style and format that was clear and consistent. For example, in Case Study 6, the first part of the "Delphi Briefing Document" presented a brief description of the situation, the alternatives, the affected environment, and the affected groups; the second part then presented, for each impact (defined as either a cost or benefit) in turn: (1) a definition of the impact; (2) a listing of the different social groups that would be differently affected by the impact; (3) a description of the nature of the impact; (4) a discussion of the magnitude of the impact; and (5) (if applicable) a description of the mitigation measures that were planned. Several panelists commented that this presentation made the impact report a useful reference tool in accomplishing the evaluation tasks.

Judging the Significance of Impacts

The task of greatest research interest in this study was to develop an acceptable approach to evaluating the relative significance of impacts. The reason why this procedure is regarded as being so important is that the efficiency criterion is the criterion which appears to be most widely accepted and which has particularly great influence in resource decision making.

The Significance Measurement Technique has been tested in a number of applications (a total of 16 panels of 8 to 24 persons each evaluated two or more lists of impacts) and the technique has substantially met the tests that were applied for determining whether the technique improves group judgments. Specifically, there was movement toward consensus as evaluations were repeated; the final impact rating scores were normally distributed; and the impact weighting scores of different panels were well-correlated. In addition, the technique was found satisfying by the panelists themselves; typical comments were that the procedures helped to clarify and refine their thinking, and that the combined judgment of the group was probably more trustworthy than their own personal judgments.

The essential nature of this task is to judge how all members of present-day society would feel (if they had the best-available information and were acting as impartial observers) as to the relative importance, value, utility or significance, of a list of forecast outcomes associated with a proposal. This is obviously a most difficult task, but resource allocation decisions require that judgments of this kind be made (along with other kinds of judgments, including judgments about fairness and sustainability).

Since this task is intended to provide data which can be used to determine whether a proposal is efficient, or is more efficient that a competing proposal, it is important to separate judgments concerning equity and sustainability from those of efficiency. Therefore, panelists are presumed to be able to distinguish between these considerations for the purpose of ascribing rating and weighting scores. While it may be arguable whether panelists can in fact do this, it is maintained that even if there is some confusion as to the extent to which other criteria are influencing rating and weighting judgments, this does not detract from the value of the exercise, particularly since the same confusion will influence the judgments of the ultimate decision maker.

Because of the inherent difficulty in judging the relative significance of impacts on an interval scale, the panelists are first asked to spend considerable time and effort in rating the impacts. It seems preferable to put extra effort into the relatively simply rating procedure in order to gently introduce the panelists to the task of judging the relative significance of the impacts, and then to gradually move into more difficult and complex scaling judgments. Only after panelists have become intimately familiar with judging the importance of the impacts using a rating scale are they asked to accomplish the much more difficult task of weighting the impacts using a ratio-scoring procedure. Rating is particularly valuable when there are a large number of impacts to be weighted, since before ratio-scoring can be done it is important to first rank-order the impacts, and this can easily be accomplished once the impacts have been rated.

Panelists did not experience any serious difficulties with the 7-point rating scale, which seemed to provide a reasonable spread of possible responses; consideration had been given to using a 5-point scale, but panelists felt comfortable that they could discriminate between seven levels of importance, and this greatly facilitated the ranking process. A 9-point or higher scale would have not helped significantly to achieve a ranking of the impacts, and could have made the rating procedure laborious and confusing.

Three iterations with feedback (plus a fourth iteration without feedback just before the rating) was found to be manageable and useful. The provision of three rounds of feedback helps to focus attention on areas of disagreement, and provides greater opportunity for anonymous debate and careful reflection. It was found that the third iteration often improves consensus, and panelists seemed to welcome two rounds of comments as well as the third feedback of histograms before making their final judgments.

Ranking of impacts was a straightforward exercise, but a few panelists had difficulty with the ratio-scoring procedure. While some individuals are just not comfortable with using a ratio scale, most people intuitively understand the ratio concept and seem able to apply it with ease. Nevertheless, the scaling or weighting process requires careful concentration, and many panelists found this part of the procedure particularly demanding and exhausting. It was not thought necessary to have a second iteration of weighting because panelists had already given considerable thought to the relative importance of the impacts during the rating process, and judgments are not likely to be improved by a second iteration of weighting; in addition, panelists are not likely to be very receptive to the idea of conducting any further evaluations at this stage.

The ratio-scoring procedure is based on a procedure suggested by Edwards (1977), who pointed out that there is greater likelihood of finding common ground amongst a group of individuals at the lower end of a scale. This led to what is believed to be an original contribution to knowledge: the concept of the "threshold of significance", and the suggestion that the "threshold impact" may constitute an acceptable common point of origin which will permit the aggregation of judgments by a number of people. It was postulated that using procedures similar to those suggested by Edwards, and assuming that two evaluation panels are similar in certain respects, the judgments by these two panels would be essentially the same. This would indicate that the evaluation procedure would constitute a reliable means of determining the relative significance of a list of unpriced impacts. If such a procedure can be shown to produce results which are consistently replicable, then it may gain acceptance as an aid to decision making, particularly in cases which are highly controversial.

The results of the tests have been positive. The Significance Measurement Technique has been applied by 16 panels evaluating a total of 33 lists of impacts. The technique has substantially met tests that have been devised for determining whether a procedure improves group judgment; for example, there is almost always movement toward consensus over three iterations of rating, and distributions on the third iteration are almost always unimodal. In addition, replicability was assessed for 95 pairs of impact lists involving 13 panels, and the weightings were consistently well-correlated.

The Delphi procedures thus appear to be effective in bringing about improvements in group judgment. The restrictions on group interaction serve to reduce emotional influences that could distort subjective value judgments, yet there is an effective means of communicating important factual information (through anonymous written comments). The controlled feedback on group thinking (through histograms and written comments), and the iterative nature of the evaluation procedure, serve to dampen cognitive dissonance and bring differences of opinion under closer scrutiny, and encourage panelists to examine their value judgments more deeply.

Nevertheless, some panelists felt that they would like to communicate more freely, and therefore consideration might be given to providing opportunities for debate and discussion in another forum (perhaps after the site visit, or the review of the impact report). Others thought that in spite of being given a warning about the band-wagon effect, there was still subtle pressure to conform to group thinking; therefore this warning should be given repeatedly during the Delphi session. (In any case, this objection - which has often been raised about the Delphi Method - is perhaps not quite so serious in this case since the final output consists of the weightings, and these are done once only and cannot be directly influenced by feedback.)

The technique can be accomplished at low cost, either in a meeting or by post. Tests indicate that both approaches can produce satisfactory results. In addition, there are indications that it is not essential for the panelists to be involved in the impact identification and definition process, so long as considerable attention has been given to this critical task. The characteristics and composition of the panel may also not be so important, so long as the panelists are acceptable to the key parties, and there are enough panelists to create a group dynamic and provide adequate feedback. While more research is required to confirm these conclusions, the results of the testing in Case Study 4 indicate that the Significance Measurement Technique is more robust than was first thought.

If the technique is applied in a meeting situation, it can produce evaluations of two proposals in less than four hours. The use of a microcomputer to speed feedback of histograms during the rating procedure helps maintain panel interest and concentration. The microcomputer (which is widely available now in South Africa) is not, however, essential. The equipment that is essential for conducting the evaluation is relatively simple and readily available, and the forms that must be completed are easy to understand and use. The mechanics of the evaluation process are not difficult to follow, so that people can be quickly instructed to perform the needed tasks; in addition, there is some flexibility in how to conduct the major procedures, so as to accommodate particular circumstances.

It is concluded that the Significance Measurement Technique constitutes a reliable and cost-effective approach to determining the relative significance of all the outcomes of a proposal. This means that it is possible to obtain subjective value judgments in a way that is relatively objective, which should improve the acceptability of such data. While no claim can made for the validity of subjective data, the fact that these data are replicable should greatly increase their credibility and usefulness in environmental evaluations and resource management.[1]

Applying the Criteria

Comparatively little attention was given to this task because the focus of the research was on developing and testing the technique for judging the relative significance of impacts.

1 A discussion of how this information can be used to determine if a proposal is efficient or not is discussed in a later sub-section of this chapter (see Analyzing the Results).

Nonetheless, this is obviously a vitally-important task which warrants far more attention than has been possible to give to it in this study.

Many approaches have been developed for applying multiple criteria to a decision making problem (see Appendix D). While any of these methods can be used to trade-off the evaluation criteria, most are relatively complex and - to one not trained in higher mathematics - even arcane. In addition, the application of these methods is generally time-consuming and requires considerable effort. Hence these approaches are not likely to achieve a high level of acceptance in the type of decision making environment which prevails in South Africa. For these reasons, a simple technique was developed during the course of this research which - while very unsophisticated - at least draws attention to the essential nature of the problem, and forces individuals to approach the problem in a systematic way, and to articulate the reasoning they would apply to the trade-offs involved.

The Criteria Trade-off Technique is normally applied at the end of the Delphi meeting, after the panel has applied the Significance Measurement Technique. By this stage, the panel has spent considerable time judging the relative significance of impacts associated with competing proposals, and for this reason (as well as other practical reasons) the technique calls for the efficiency criterion to be applied first. In applying the Significance Measurement Technique, panelists have not explicitly considered whether total costs exceed total benefits, but by the time the comparative evaluations of impact significance are done panelists seem to have developed a good feel for whether the proposal would be efficient or not. They have also given some thought as to which social groups would be differently affected, and what the implications would be for future generations.

Panelists did not find it difficult to write short statements applying each of the three evaluation criteria. But the next step - trading-off the criteria - was found to be more difficult. Several panelists complained that such difficult judgments should not be attempted at the end of an evaluation exercise that was primarily directed at accomplishing other objectives.

Therefore it may not always be desirable to try to accomplish this important objective at the end of the panel meeting; this depends on the perceived difficulty in trading-off the criteria in a particular case. For example, in Case Study 3 a separate meeting was organized to apply and trade-off the evaluation criteria, but the panelists who participated felt that the results were so obvious that the special meeting was a waste of time. By contrast, most of the panelists involved in Case Study 4 appeared to find the situation more complex and the trade-offs more difficult, and some complained that it was quite demanding and tiring to apply the technique. This was confirmed by a review of their personal evaluation statements, which indicated that there was much doubt and confusion among panelists in applying the criteria.

In Case Study 6, more attention was given to this task because the brief was to first identify the most promising proposal, and then determine whether the benefits of this proposal would exceed its costs. It was decided to reverse the usual procedure and apply the Criteria Trade-off Technique to determine which of three proposals best satisfied all three evaluation criteria, and then to apply the Significance Measurement Technique to determine whether this proposal would have a net benefit. The iterative rating procedure was used to apply the Criteria Trade-off Technique, and there was good agreement as to which of the three proposals was superior. This variation of the Criteria Trade-off Technique was judged successful, and it is felt that this approach warrants more development and testing.

Analyzing the Results

This task is concerned with providing the decision maker (and all concerned parties) with a rational and lucid account of how the proposals measure up in terms of the specified evaluation criteria. There are two major aspects to this task:

- analyzing the results of the Significance Measurement Technique to determine which proposal best satisfies the efficiency criterion; and

- analyzing the results of the Criteria Trade-off Technique to determine which proposal best satisfies all three criteria taken together.

The Efficiency Determination

There are two ways of employing the Significance Measurement Technique to make efficiency determinations: the fractional contingency price valuation procedure, and the comprehensive valuation procedure. After testing both approaches, it is concluded that the comprehensive valuation procedure is to be preferred.

The fractional contingency price valuation procedure is judged to be of marginal value in conducting formal evaluations. Although the basic concepts are simple enough, the application of the procedure is rather intricate and involved, and may not be readily accepted by decision makers and the general public (particularly in the case when the alternatives being compared both have significant costs and benefits, and it is necessary to make rather abstruse adjustments before fractional contingency prices can be calculated). In addition, two fundamental problems arise in applying this procedure:

- The procedure has an aura of precision which is misleading, since it involves mathematical operations which imply that relatively precise estimates of the relative significance of unpriced impacts can be obtained.

- The procedure requires the calculation of the excess monetary value of one proposal over another, and the data necessary to do this will not always be available.

The first problem is that judgments of impact significance may simply not be considered sufficiently reliable to calculate fractional contingency prices in which one has real confidence. The variation in impact weightings that can be expected between panels is great enough to result in fractional contingency prices that would not meet sensitivity tests in many cases. In addition, there is the possibility that fractional contingency prices for different impacts would result in different judgments, partly because of an insufficient standard of reliability, and also because one would expect some degree of intransitivity in making judgments when several different impacts are judged against different monetary values.

The second problem is that in order to calculate the excess monetary value of one proposal over another, it is necessary to know the present discounted value of the proposals. But resource limitations in South Africa (and many other developing countries) often preclude the application of formal Cost-benefit Analysis, or result in inaccurate or misleading results. Finally, not all of the financial implications of a proposal can always be captured or adequately conveyed in a single figure, particularly for programme or policy proposals. In any case, there is no real reason to base the evaluation on a monetary measure; what is important is whether (and to what extent) total benefits exceed total costs using some "measuring rod" (such as significance intervals based on ratio judgments), and therefore the financial implications can simply be described and listed as benefits (if positive) or costs (if negative).

Since it was decided that it was not necessary or desirable to use the fractional contingency price procedure, the last three case studies done for this dissertation involved the application of the comprehensive valuation procedure. Financial implications were listed along with other outcomes, so that their value relative to unpriced outcomes could be judged. In the first of these studies, Case Study 4 (the Palmiet case study), all outcomes were expressed as benefits in order to reduce the number of lists that had to be evaluated. This approach - which is believed to be original - had mixed results. While it did shorten and simplify the evaluation process to some extent, some panelists found it difficult to conceptualize the value of those "direct benefits" which were offered by both proposals but differed in degree, and felt uncomfortable with the concept of considering as "indirect benefits" the costs that would result if the alternative proposal were chosen.

In the next two cases, the Infanta and Sandton case studies, panelists were asked to evaluate a list of costs and a list of benefits for the proposals under consideration. Again, financial implications were listed along with nonmonetary implications so that they could simply be scaled against unpriced impacts. This seemed to be more acceptable to the panelists, but there was then the question as to whether the weights assigned to costs could legitimately be aggregated with those assigned to benefits in order to determine whether costs outweighed benefits. A related question is whether evaluations of the net benefit calculated for different proposals can be compared. The answer depends on whether the variation in the value of the threshold impacts on different lists is judged to be within acceptable limits.

In Case Study 6, panelists were asked to indicate whether the threshold impact on the list of costs was equivalent in significance to the threshold impact on the list of benefits. Only three of 13 panelists felt that they were not equivalent, and even these three panelists indicated that the variation was not particularly great. While this is certainly not conclusive evidence that one may regard the threshold impacts on two lists as constituting a common point of origin, it is encouraging that the panelists in this case were satisfied that they were, and that the weightings on the two lists could be aggregated. Nevertheless, further research needs to be done to determine just how reliable this purported common point of origin is, and what might be done to ensure that threshold impacts on two lists are of comparable significance.[2]

Identification of the Preferred Proposal

Once the efficiency determination has been made, it is necessary to analyze the proposals in terms of the other two evaluation criteria, and suggest which proposal is in the best overall interests of society. The analysts responsibility here is to accurately summarize the personal evaluation statements, and clearly communicate to the decision maker the reasoning behind the judgments made by the panelists. While the personal evaluation statements that were obtained during the course of this research were generally unsatisfactory, it is felt that if careful attention were given to explaining the Criteria Trade-off Technique to the panelists, and sufficient time were allowed for the preparation of these statements, they could prove to be most helpful to the decision maker in undertaking this difficult task himself.[3]

CONCLUSION

In conclusion, a philosophy of resource evaluation and management has been presented which provides both a way of thinking and a guide to action that should be acceptable to persons with diverse views, responsibilities and interests. Of particular importance, a formal evaluation method for utilizing group judgments has been developed for especially contentious or controversial resource allocation proposals. This method - the Panel Evaluation Method - has been designed to take advantage of available expertise, obtain informed opinion from respected parties, and provide a thorough and practical evaluation of the implications of the leading alternatives in terms of criteria relevant to resource allocation decisions.

The Panel Evaluation Method has been demonstrated to improve group judgments and produce reliable results. In addition, the method has proved to have low resource requirements, and to be easy to apply, cost-effective, versatile, and applicable to virtually any resource allocation decision. In fact, each of the six case studies that were undertaken during the course of this study involved a different kind of resource allocation decision and a different type of

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2 One interesting test would be to combine costs and benefits on one list and ask individuals to undertake repeated measures of three or more impacts, in different sets of impacts, along a positive-negative continuum. The object would be to determine whether scale values (weights) are invariant (consistent) with respect to the values of the remaining impacts in the set (and in agreement with the values assigned using the standard Significance Measurement Technique), and the conditions necessary to achieve this.

3 It would be interesting to use the general procedures associated with the Significance Measurement Technique to see if one could obtain more refined and replicable results in applying evaluation criteria (through the iterative process of rating with feedback) before panelists prepare their final personal evaluation statements.

conflict. Some of these case studies also involved the application of one or more evaluation techniques in addition to those that comprise the Panel Evaluation Method. These results serve to demonstrate the general adaptability and flexibility of the method. Finally, the results of the testing programme indicate that the Panel Evaluation Method produces useful results, and has high user acceptability.

A major advantage of employing the Panel Evaluation Method is that the busy decision maker can then carefully review the results of a thorough, independent and respected evaluation to see whether he is in agreement, or whether re-evaluation of some questions might be desired, or whether different conclusions might be drawn. In this way, the decision maker is not operating in a "vacuum" -

- he benefits from the experience and intuition of others;
- he can be assured that a comprehensive and clearly-defined list of impacts has been generated;
- he can point out to his constituencies that a systematic and unbiased evaluation of their concerns has been accomplished;
- he can refer to both quantitative and qualitative evaluations (*viz.*, the Significance Measurement Technique and the Criteria Trade-off Technique) in which subjective value judgments have been made explicit;
- his attention can be focused on the truly significant possible outcomes;
- he should be less vulnerable to having his judgment distorted by those with special interests, and less subject to influence by individuals who happen to have ready access to him;
- he might find his personal judgments substantiated and so be able to cite support for his decision;
- he will be inclined to carefully reconsider points where disagreement exists; and, finally,
- he will feel more inclined to justify his final decision and clearly explain his position when disagreement persists.

All this is in the best interests of both the decision maker and society: the procedures which comprise the method encourage best use of the always imperfect information which is available, so that resource allocation decisions will be improved and better received by all concerned.

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APPENDIX A

THE HISTORICAL DEVELOPMENT OF ENVIRONMENTAL EVALUATION

In recent years, there have been many attempts to develop practical assessment and evaluation procedures for resource allocation proposals. This appendix presents a brief history of how Environmental Impact Assessment and environmental evaluation has evolved both overseas and in South Africa.

The Development of Environmental Impact Assessment

The Limitations of Cost-benefit Analysis

One of the first formal methods that was developed to evaluate the economic, social and environmental consequences of alternative resource allocation actions was Cost-benefit Analysis, which was initially applied to major water resource projects in the United States in the 1930's (Kneese, 1984; Pearce, 1983). While this method (see Cost-benefit Analysis in Chapter 3) has since been widely used in a variety of applications (Abelson, 1979; Common, 1988; Mishan, 1975) it has been criticized for its failure to give adequate treatment to the sometimes substantial nonmonetizable social and environmental costs associated with some proposals, and the failure to adequately consider the different implications for various social groups and future generations. In the United States during the 1960s these criticisms grew with increasing evidence that major developments were having unacceptable side-effects, and there was a groundswell of public opinion that some mechanism was needed to ensure that unpriced social and environmental costs would be given adequate consideration in the decision making process (Clark, 1984; Pearce, 1983).

The National Environmental Policy Act

These concerns finally resulted in passage of the National Environmental Policy Act on January 1, 1970. This act, among other things, legislated a new requirement that agencies must prepare an Environmental Impact Statement when considering any federal or federally-funded action which could significantly affect the quality of the human environment (United States, 1969:Sec.102[2][C]). The process which was to guide the preparation of the Environmental Impact Statement became known as Environmental Impact Assessment, which has been defined as the administrative process by which the environmental impact of a proposed action is determined (Fuggle, 1983:488). The object of the Environmental Impact Assessment was to provide information that would help agencies decide whether the adverse environmental impacts of projects outweighed their benefits.

Environmental Impact Assessment

Environmental impact assessment is generally understood to be the investigation and documented analysis of any proposed action that could have adverse consequences for the human environment. While Cost-benefit Analysis is directed at "weighing up" both beneficial and adverse outcomes to produce an explicit evaluation of a proposal (Pearce, 1983), Environmental Impact Assessment is directed at providing information about adverse impacts so that a proposal can be improved, or so that a comparatively informal or implicit evaluation can be done to determine whether the proposal should be adopted (Hollick, 1986). In fact, Environmental Impact Assessment was developed because some mechanism was needed to generate data for improving a proposal, and for ensuring that adequate consideration was given to unpriced impacts. This was because with many resource allocation proposals the problem was not just simply determining whether benefits exceeded costs (this was often - though not always - fairly obvious) or by how much (this was often not really germane), but rather whether adverse impacts could be avoided or mitigated, and how the proposal could be made acceptable to all concerned parties.

In the early days of Environmental Impact Assessment, emphasis was placed on investigating and documenting impacts on the "natural" (or biophysical) environment, and giving some indication of how these impacts would affect social well-being (Conover *et al.*, 1985). Direct impacts to the "human" (or socioeconomic) environment were often left to Cost-benefit Analysis or some other type of assessment, such as "*Social Impact Assessment*" (Finsterbusch, 1985; Finsterbusch and Wolf, 1977; Lang and Armour, 1981; U.S. Army Engineers, 1975). But in more recent times, in the U.S. and elsewhere, the term Environmental Impact Assessment has come to mean an investigation into any action that

- could potentially affect social well-being, directly or indirectly, through impacts on either the natural or human environment, and

- results in a document which explains how social well-being would be affected by these impacts, recommends measures to avoid or mitigate these impacts, and analyzes alternatives to the proposed action (Bisset, 1987; Hollick, 1986).

While the National Environmental Policy Act required an Environmental Impact Statement to be prepared for any action which could significantly affect the environment, it did not precisely define what was meant by the terms "action" or "significantly", nor did it attempt to prescribe what methods and techniques should be used to undertake environmental assessment. The framers of the Act did call for all agencies of the federal government to "utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment" (United States, 1969:Sec.102[2][A]). The U.S. legislators also called for the development of new methods and techniques for evaluating the significance of impacts on the quality of the human environment "which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical considerations" (United States, 1969:Sec.102[2][B]).

Environmental Evaluation

Since the passage of the National Environmental Policy Act many methods and techniques of environmental assessment and evaluation have been developed in the United States and elsewhere. Early methods consisted of essentially mechanical processes for gathering, organising and communicating data, such as checklists, matrices, overlays, and networks (Shopley and Fuggle, 1984; Bisset, 1987). In these early methods, emphasis tended to be on ensuring that potential impacts were identified, and less attention was given to ensuring that these impacts were adequately defined or described (Lee, 1982). In addition, although these early methods often called for explicit evaluations of impacts, in most cases such evaluations were not conducted in a rigorous manner, and were accomplished by one or more analysts with no special standing in the eyes of the decision maker or society as a whole.

Subsequently, greater attention was given to developing more formal evaluation methods which were often tailored to particular applications (*e.g.*, water resource development projects), such as the Environmental Evaluation System (Dee *et al.*, 1973) and the Sondheim Method (Sondheim, 1978). These methods also had serious shortcomings, such as relatively great resource requirements (*e.g.*, time, money and manpower) and inbuilt rigidities which made it impractical to adapt them to many specific resource allocation problems.

Today most practitioners of Environmental Impact Assessment throughout the world have adopted procedural mechanisms for guiding analyses of competing resource allocation proposals, and rely on relatively informal evaluations rather than special techniques or formal methods of assessment and evaluation (Hollick, 1986). No single "*technique*", "*method*" or set of "*procedures*" has been found to have universal applicability, nor has a satisfactory "*methodology*" of environmental evaluation been developed (Beanlands and Duinker, 1984; Bisset, 1987; Haug, 1984a; Lee, 1982).

Warner and Preston (1974) found that in the early 1970's none of the more well-known assessment or evaluation methods and techniques had been adopted or used by any federal agency after initial trials. Bisset (1980) confirmed that at the end of the 1970's, despite an increase in the number of complex methods based on numerical computations, no method had emerged which met all the criteria which had been established for undertaking impact analyses. In both the United States and the United Kingdom, there were indications that quantitative methods would play a decreasing role in impact analysis, and there was a need for methods which providing information in a qualitative, disaggregated form (Bisset, 1980:27; Hollick, 1981a).

This situation has continued into the 1980's. Hollick (1986:163) states that Environmental Impact Assessment techniques for quantifying environmental social values, such as matrices and scaled checklists, have generally been found wanting and the use of such methods is now comparatively rare. Moreover, there has been a trend away from concern with formal procedural issues toward concern with the effectiveness of Environmental Impact Assessment in actually reducing environmental impacts, and the efficiency of the process (Hollick, 1986:158). Emphasis has shifted from numerical evaluation techniques toward more political evaluation processes (Hollick, 1986:175).

In the United States, agencies have begun adopting a relatively unstructured and nonmechanical approach to assessment. The assessment process is now generally guided by common sense and the exigencies of particular situations, and the evaluation process emphasizes qualitative rather than quantitative data. Most agencies have developed general guidelines for conducting Environmental Impact Assessment, within which specific methods and techniques of assessment or evaluation can be applied if deemed appropriate (Paine, pers. comm.).

Meanwhile, in the Third World, Biswas and Geping (1987:192) maintain that it is now quiet evident that detailed, expensive, time-consuming and sophisticated Environmental Impact Assessment techniques that were developed for the First World are unlikely to be of much practical value for use in developing countries in an operational sense. Among the general principles that Biswas and Geping (1987:193-194) list to guide the development of Environmental Impact Assessment in the Third World are the following:

> EIA reports should be presented in a simple form so that decision-makers can readily digest and make use of the analysis in making rational decisions.... EIA should aim at maintaining the availability and use of natural resources on a sustainable basis.... expected changes in environmental values, which often can only be considered in a subjective way, have to be taken into account in the decision-making process.... legal and institutional mechanisms need to be simultaneously developed ...

Biswas and Geping (1987:204) also suggest that extended Cost-benefit Analysis methods are more appropriate for developing countries than conventional Environmental Impact Assessment methods.

Environmental Impact Assessment is a process that is still evolving to respond to deficiencies in the environmental resource allocation process (Caldwell, 1987; Eplan, 1987; Hill, 1987). Many Environmental Impact Assessment methods and techniques are now available to guide resource allocation decisions, and these should be considered for inclusion in any formal methodology for environmental evaluation. But historically Environmental Impact Assessment has been reactive in nature and restricted in scope, and this has limited the effectiveness and acceptability of traditional Environmental Impact Assessment methods (Burton *et al.*, 1983; S.A. Council for the Environment, 1989; Westman, 1985). Just as the horizons of conventional Cost-benefit Analysis have needed expanding to provide more relevant criteria and stimulate more innovative techniques for incorporating unpriced values in the decision making framework (Herfindahl and Kneese, 1974; Pearce, 1983), so the horizons of conventional Environmental

Impact Assessment have needed expanding to make it more positive and relevant to the entire resource management process. Specifically, there has been a need to integrate all aspects of development and conservation activities in a broader framework of environmental planning, assessment, decision making and management (see The Concept of Integrated Environmental Management in Chapter 4).

The following section presents a brief review and critique of some of the more well-known methods and techniques of Environmental Impact Assessment.

Early Approaches to Environmental Impact Assessment

Many methods and techniques of Environmental Impact Assessment have been developed since the passage of the National Environmental Policy Act in the United States. Most of these fall into one of the following categories: checklists, matrices, overlays, networks, and special or ad hoc methods (Shopley and Fuggle, 1984; Munn, 1975). Each of these categories will be briefly discussed in order to convey some appreciation of the relative strengths and weaknesses of different approaches to Environmental Impact Assessment, and indicate the kinds of situations to which each is most appropriate.[1]

Checklists

A checklist is simply a listing of items which is to be used to guide thinking or action in some undertaking. In Environmental Impact Assessment, there are two major types of checklist:

- those which list possible or anticipated actions associated with a proposal, and
- those which list environmental characteristics that could be affected by these actions (see Box A.1).

Checklists are primarily intended to be aide-memoirs. They are often used in the early stages of an Environmental Impact Assessment to develop a better understanding of both the proposed action and the affected environment, in order to ensure that all environmental considerations will be taken into account. A useful approach is to create tailor-made checklists for each new study during proposal discussions and site visits, and then use more general lists to double-check that nothing of possible significance has been left out. The checklist can then be used to guide the Environmental Impact Assessment investigation and report writing. For example, a checklist of environmental characteristics will be useful in suggesting which aspects of the environment should be thoroughly investigated and discussed; similarly, a list of proposed actions would be a useful reference when examining and reporting on how the various environmental characteristics could be impacted.

The major advantage of the checklist is that it helps ensure that both the investigation and the report will be comprehensive. The major disadvantage of the checklist is that, unless it has been created for or adapted to the proposal being considered, it may confine thinking so that unusual characteristics (of either the proposal or the environment) may be missed. In addition, checklists alone are not particularly helpful in identifying cumulative or induced impacts. Finally, there is a tendency for many practitioners to become preoccupied with ensuring that all items appearing on the checklist are addressed, and to believe they have done an adequate job if they have reported on each characteristic and each action; the too-frequent result is overlong, tedious, unbalanced assessments, which often fail to analyze the more serious impacts in sufficient depth.

1 This brief survey is intended only to indicate some of the more common approaches that have been taken to dealing with the great complexity inherent in the task of environmental assessment.

BOX A.1
Example of Checklists for Project Actions and Environmental Elements
(from Leopold *et al.*, 1971)

PROJECT ACTIONS
A. Modification of Regime
(a) Exotic flora or fauna introduction
(b) Biological controls
(c) Modification of habitat
....
B. Land Transformation and Construction
(a) Urbanization
(b) Industrial sites and buildings
(c) Airports
....
C. Resource Extraction
(a) Blasting and drilling
(b) Surface excavation
(c) Subsurface excavation and retorting
....

ENVIRONMENTAL ELEMENTS
1. Earth
(a) Mineral resources
(b) Construction materials
(c) Soils
....
2. Water
(a) Surface
(b) Ocean
(c) Underground
....
B. Biological Conditions
1. Flora
(a) Trees
(b) Shrubs
(c) Grass
....
2. Fauna
(a) Birds
(b) Land animals including reptiles
(c) Fish and shellfish
....

Matrices

Matrices are formed by arranging one checklist on a vertical axis, and either the same checklist or another checklist on a horizontal axis, so that every pair of elements are made to intersect at a unique point. This point can either be an intersection of two lines, or a cell created by the intersection of two sets of parallel lines (see Figure A.1).

The principal object of a matrix is to ensure that all the potential effects of an action are identified. This is done by drawing attention to the possible interaction of every element on one list with every element on the other list. For example, if project actions are listed on one axis and environmental characteristics on the other axis, the matrix provides a means for ensuring that the potential impact of every action on every characteristic will be recognized so that it can then be assessed.

The Leopold matrix (Leopold *et al.*, 1971) was the first matrix method to be used for Environmental Impact Assessment. This matrix provides a list of 88 project actions and 100 environmental characteristics, which yields 8800 possible interactions. Instructions for using the matrix are that each interaction is to be assessed and if an impact is judged to be possible, then that impact is scored on a scale of 1 to 10 in terms of magnitude and then of significance (see Figure A.1).

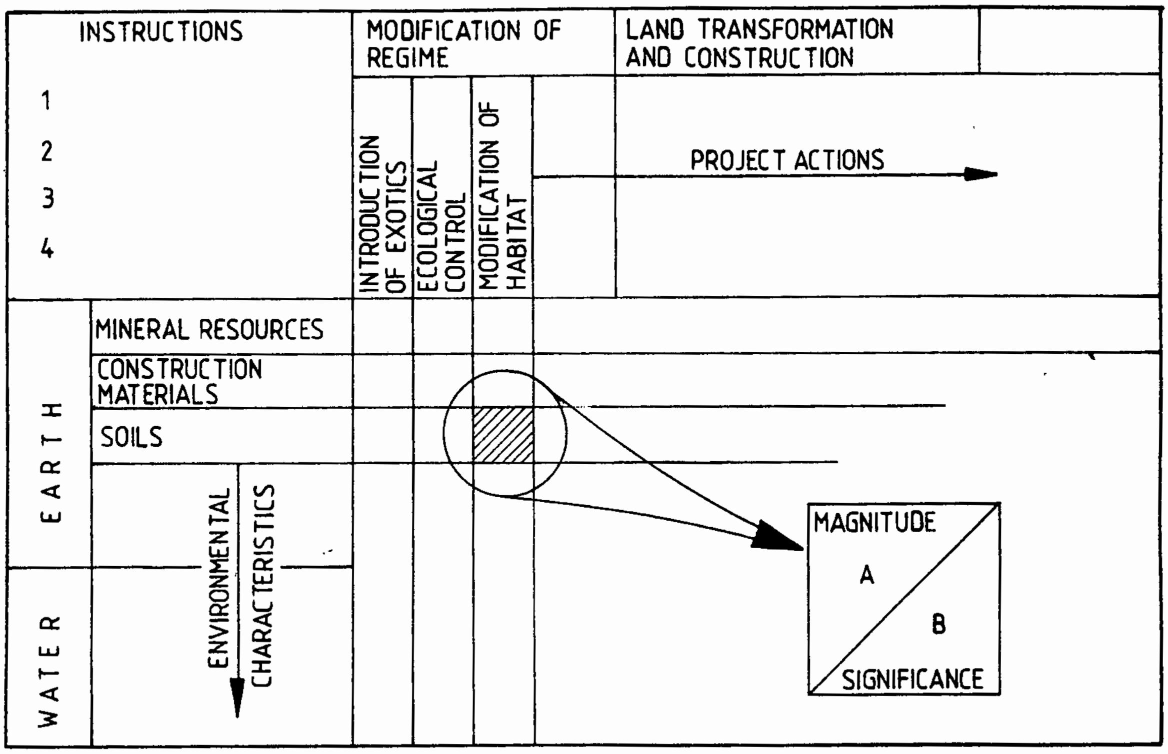
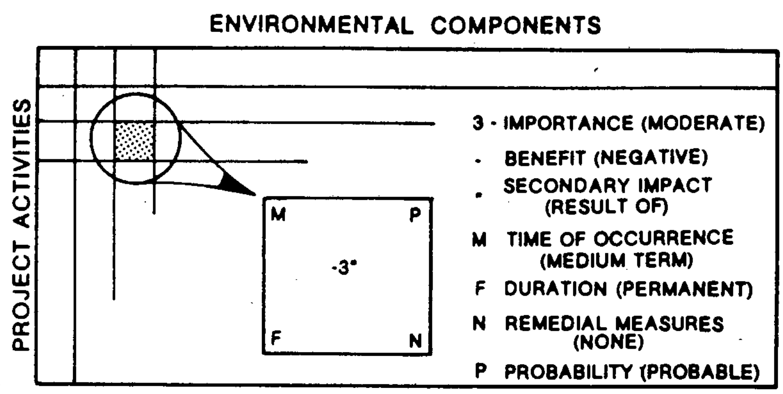


FIGURE A.1 Matrix Format

The Leopold matrix is somewhat unwieldy because of the great number of possible interactions, but the original matrix can be scaled down if necessary by eliminating some of the elements on each axis. Another difficulty with the Leopold matrix is that there is no guidance or set of procedures for making magnitude and significance assessments, and the quality of judgments by the analyst or evaluator may rapidly decline due to the tediousness of the task. In addition, one might question the authority and qualifications of the person who will be making these crucial judgments, particularly the significance judgment. Finally, no provision is made to obtain other potentially useful information about the impact, such as its nature, timing, duration, probability of occurrence, risk, and potential for giving rise to higher-order impacts. If one is going to consider these factors in another format, in which more descriptive information can be presented (Haug *et al.*, 1984a, 1984b), then perhaps magnitude and significance should also be judged separately, and the matrix could simply be used to serve a checklist function: to identify whether an interaction will result in an impact or not.

The Fuggle matrix was developed to extend the capabilities of the Leopold matrix by providing for more information to be gathered and displayed. The Leopold matrix jumps from the impact identification stage to the impact evaluation stage without any mechanism for systematically describing characteristics of an impact that would be important to the act of evaluation. The Fuggle matrix features a mechanism which draws attention to salient characteristics of the impact that should be considered before judging the impact's magnitude and significance. In this matrix, magnitude and significance have been collapsed into one assessment of "importance", which is assessed only after other characteristics of the potential impact have been assessed, *viz.*, timing, duration, probability of occurrence, risk, potential for giving rise to higher-order impacts, and whether negative or positive (see Figure A.2). The elements which comprise the matrix are to be generated for each proposal to be assessed, in order to keep the number of possible interactions to be assessed to a minimum (see Figure A.3). Because of the amount of information to be displayed, Fuggle recommends preparation of a "Summary Matrix", after the original matrix has been completed, which indicates by symbols those interactions that are of special interest (see Figure A.4); this enables one to readily see which project actions or environmental characteristics should receive special attention.



ENTRIES IN MATRIX CELLS

CHARACTERISTIC EVALUATED	SYMBOLS USED	MEANING	POSITION IN CELL
IMPORTANCE	5	Major	5
	4		
	3	Moderate	
	2		
	1	Minor	
	?	Unable to determine	
PROBABILITY	C	Certain	C
	P	Probable	
	U	Unlikely	
	?	Not known	
TIME OF OCCURRENCE	I	Immediate	I
	D	Delayed	
	L	Long-term	
	?	Not known	
DURATION	T	Transient	
	S	Short	S
	F	Permanent	
	?	Not known	
BENEFIT	+	Positive	+
	–	Negative	
	?	Not known	
REMEDIAL MEASURES	Y	Planned	Y
	N	Not planned	
	?	Not known	
RISK	!	Potential hazard	!
SECONDARY IMPACTS	*	Will give rise to	*
	•	Is a result of	

FIGURE A.2 Instructions for Completing Fuggle Matrix (from Fuggle, 1983)

ENVIRONMENTAL IMPACT ASSESSMENT MATRIX

CONSTANTIA HYPERMARKET

DATE: SEPTEMBER, 1979.

EXISTING CHARACTERISTICS OF THE ENVIRONMENT

ACTIONS WHICH MAY CAUSE ENVIRONMENTAL IMPACT

GENERAL GROUPS	SPECIFIC ACTIONS	PHYSICAL & BIOLOGICAL		MAN-MADE FACILITIES & ACTIVITIES											AESTHETICS & CULTURAL INTERESTS				
		FAUNA AND FLORA	WATER RUN OFF	LOCAL TRANSPORT NET	REGIONAL TRAN. NET	LOC. UTILITY NETWORK	REG. UTILITY NETWORK	COMMERCIAL FACILIT. LOC.	COMMERCIAL FACILIT. REG.	NATIONAL FUEL RES.	VICTORIA HOSPITAL	SOCIAL SERVICES	AVENUES & ROADS	KIRSTENB. FREEWAY	VISTAS AND OPEN SPACES	SEMI RURAL QUALITY	TOURISM	HISTORIC VALUES	POST OFFICE BUILDING
CONSTRUCTION	CLEARANCE OF SITE	I C -1 F Y	I P -2 T N			? U -3 S N									I C -3 F N	I C -3 F N	I C -3 F N		
CONSTRUCTION	BUILDING NOISE															I C -3 T N	I ? -? T N		
CONSTRUCTION	DUST PRODUCTION	I C -2lo T N														I P -2 T N			
CONSTRUCTION	TEMPORARY SERVICES LOAD			I C -2 T N		I P -4 T N		I ? -2 T N											
DURING AND AFTER CONSTRUCTION	LABOUR INFLUX			I C -2 T N	I C -2 F N			I C +2 T									I C -2 T		
DURING AND AFTER CONSTRUCTION	HEAVY TRUCKS			I C -4 S N	I P -1 S Y											I C -2 F N	I C -3 F N		
AFTER CONSTRUCTION	PERMANENT SERVICES LOAD					M C -5 F ?	M C -3 F ?												
AFTER CONSTRUCTION	HYPERMARKET FACILITY							L C ?5 F	L C -4 F			L P -2 F N			L C -3 F Y	L C -5 F N	L P -2 F	L P -3 F	L C -3 F
AFTER CONSTRUCTION	PARKING AREA	L ? ?? F Y	L C -4 F N												L C -4 F	L C -5 F	L ? ?? F	L P -? F Y	L C -4 F ?
AFTER CONSTRUCTION	SHOPPING TRAFFIC			L C -5 F N	L C -3 F N					L ? -3 F	L P -4lo F N		L C -5 F N	L ? -2 F		L C -5 F N		L ? -? F	
AFTER CONSTRUCTION	WASTE PRODUCTS FROM SHOPS					L ? -? F Y							L C -1 F						
AFTER CONSTRUCTION	LITTER					L P -1 F Y							L P -1 F Y			L ? -1 F Y	L ? -? F Y		
AFTER CONSTRUCTION	IMPETUS TO FURTHER DEVELOPM''	L P -4 F		L P -5 F	L P -4 F	L P ?4 F	L P ?? F	L P +5 F	L ? -? F			L P ?? F	L ? -4 F	L ? -5 F	L P -5 F	L C -5 F	L P -4 F	L ? -3 F	
	lo = LOCAL IMPACT																		

GENERAL GROUPS	SPECIFIC ACTIONS	PHYSIOLOGICAL & PSYCHOLOGICAL WELLBEING										SOCIO-ECONOMIC PATTERNS					
		QUIET ATMOSPHERE	UNHURRIED ATMOSPHERE	AIR QUALITY	TRAFFIC: LOW HAZARD	REFUSE & LITTER (LOW LEVEL)	CRIME & VIOL. (LOW LEVEL)	VAGRANTS (LOW LEVEL)	RES./GOV. CO-OPERATION	ON SITE RECREATION	OFF SITE RECREATION	EMPLOYMENT OPPORTUNITIES	POPULATION CHARACTERISTICS	LAND VALUES	RATES AND TAXES	POPULATION DENSITIES	POPULATION: DAILY INFLUX
CONSTRUCTION	CLEARANCE OF SITE	I C -3 S N				I C -2 S Y				I C -3 F N							I C -3 S N
CONSTRUCTION	BUILDING NOISE	I C -5lo T N	I C -4 T N								I P -2 T N			M ? -? T N			
CONSTRUCTION	DUST PRODUCTION			I C -3 T N							I P -2 T N						
CONSTRUCTION	TEMPORARY SERVICES LOAD								I ? -2 T								
DURING AND AFTER CONSTRUCTION	LABOUR INFLUX	I ? -1 T	I P -1 T			I P -1 T N	I U -? T ?										I C -3 T
DURING AND AFTER CONSTRUCTION	HEAVY TRUCKS	I C -4 F ?	I C -2 F N	I C -2 F N	I C -4 F N						I C -4 F N			I P -3 F N			
AFTER CONSTRUCTION	PERMANENT SERVICES LOAD														L P ?? F		
AFTER CONSTRUCTION	HYPERMARKET FACILITY	L C -5 F	L C -4 F				L ? -1 F Y	L C -3 F ?	L P -? T	L C -5lo F			L P -1 F	L P -3 F	L C ?? F	L P -3 F	L C ?5 F
AFTER CONSTRUCTION	PARKING AREA							L C -3 F ?		L P +3 F							
AFTER CONSTRUCTION	SHOPPING TRAFFIC	L C -4 F	L C -3 F	L C -3 F	L C -4 F N						L C -3 F N			L P -2 F	L ? ?? F		
AFTER CONSTRUCTION	WASTE PRODUCTS FROM SHOPS	L C -1 F N		L U -? F Y		L ? -? F Y		L C -3 F Y									
AFTER CONSTRUCTION	LITTER					L P -2 F Y									L U -? F Y		
AFTER CONSTRUCTION	IMPETUS TO FURTHER DEVELOPM''	L ? -4 F	L ? -4 F		L P -4 F						L P -4 F	L P +3 F	L P ?4 F	L C ?? F	L C ?? F	L P ?? F	L ? ?? F
	lo = LOCAL IMPACT																

FIGURE A.3 **Example of Fuggle Matrix**

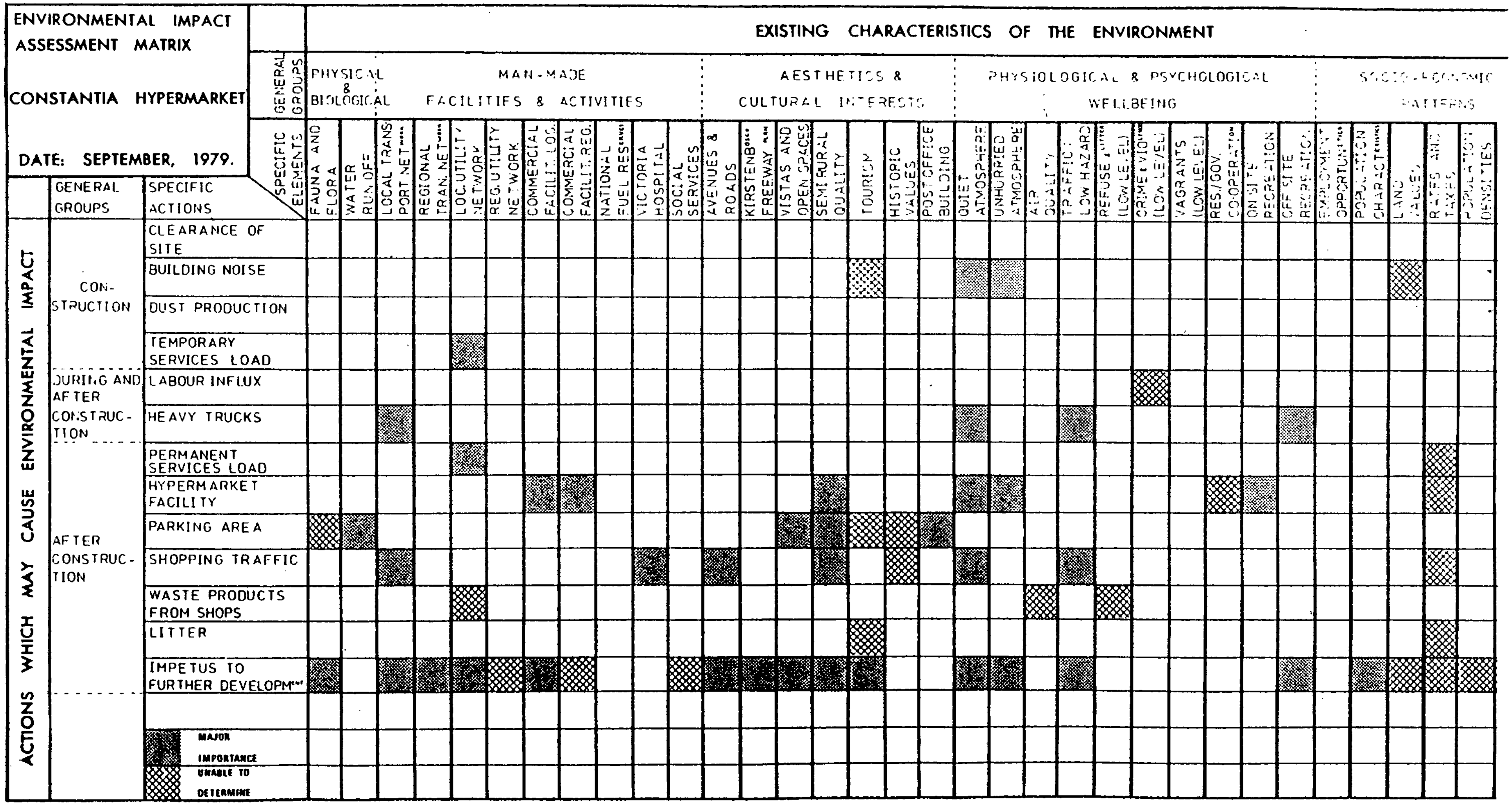


FIGURE A.4 **Example of Summary Matrix**

The Fuggle matrix ensures that more data are gathered on each impact so that the evaluation process is more systematic and thorough, and provides a convenient format for concisely displaying these data, but still requires an explanatory text to discuss the nature of each impact and the reasoning underlying the judgments. The lack of an explicit assessment of magnitude as opposed to significance may lead to more arbitrary judgments as to the social value of an impact, and, as in the Leopold matrix, it is questionable whether the researcher/assessor who is normally charged with this task is qualified to carry it out. Finally, the time required to complete the Fuggle matrix can be even greater than that required to complete the Leopold matrix, since there are a good many more judgments to be made, and the notation does not convey information as clearly as would a text in which the impacts are defined and discussed in words.

<u>Overlays</u>

Overlays were pioneered by Ian McHarg (Shopley and Fuggle, 1984). The method involves mapping individual environmental characteristics and then overlaying the various maps to get some indication of the relative suitability of particular areas for the project under consideration. For example, the major environmental characteristics relevant to a highway alignment might be slope, soils, ecological sensitivity, and aesthetic sensitivity. Each of these characteristics could be rated on individual maps covering the area through which the highway could be routed. The ratings could be "highly suitable", "suitable", "unsuitable", and "highly unsuitable" and each of these ratings could be assigned a colour code, *e.g.*, dark red for "highly unsuitable" and dark green for "highly suitable". By overlaying the maps, one can see at a glance the composite rating for all possible alignments, and the most promising alignments can be investigated further (see Figure A.5).

Overlay techniques provide an effective means of communicating the nature and extent of certain variables, but they are suitable only for proposals which are primarily spatial in character, and for which relevant criteria can be easily mapped, such as highway projects. Criteria selection and decision rules are important considerations in employing this method, and these should be carefully formulated in consultation with the client and other interested parties.

<u>Networks</u>

Network methods are directed at tracing out the pattern of "*higher-order impacts*" that may result from "*first-order impacts*", to give a better understanding of the total ramifications of a proposal. An example is the method developed by Sorensen (1971). This method graphically depicts a range of potential impacts on coastal zone resources which might be expected to result from certain developments and activities. Sorensen utilizes a stepped matrix attached to a network to display how particular resource uses give rise to causal factors that can result in adverse impacts (see Figure A.6). The diagramatic representation clearly communicates how causal factors lead to a set of initial conditions, and how this in turn leads to a set of consequent conditions which ultimately results in adverse environmental effects. The framework also makes provision for depicting corrective actions or control mechanisms.

The frameworks used in network methods normally make no provision for gathering and displaying the detailed data that would be needed for an environmental assessment or evaluation. But these methods provide an arresting visual presentation of complex cause-effect relationships, and can focus attention on higher-order impacts that might otherwise be overlooked. Networks can be useful planning tools, and can also serve a checklist function in the assessment of major actions.

LAND USE EVALUATION

National Road Route 2 Sections 7 & 8

(Kraaibos to Eastford)

SUITABILITY MAP

LEGEND

1. CLASSIFICATION OF AREA

HIGHLY UNSUITABLE

SUITABLE

SUITABLE WITH LIMITATIONS

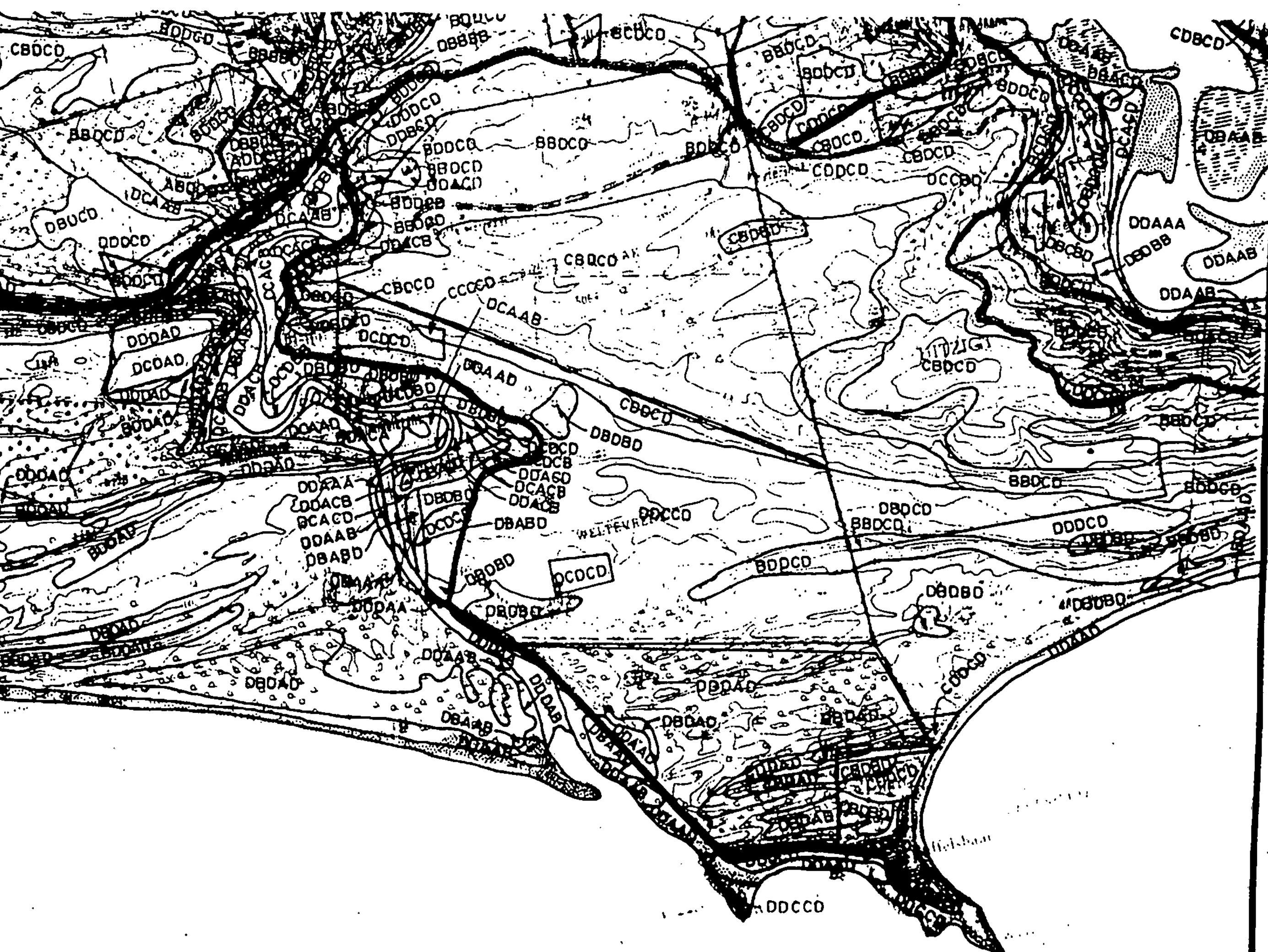


FIGURE A.5 Example of Overlay Approach

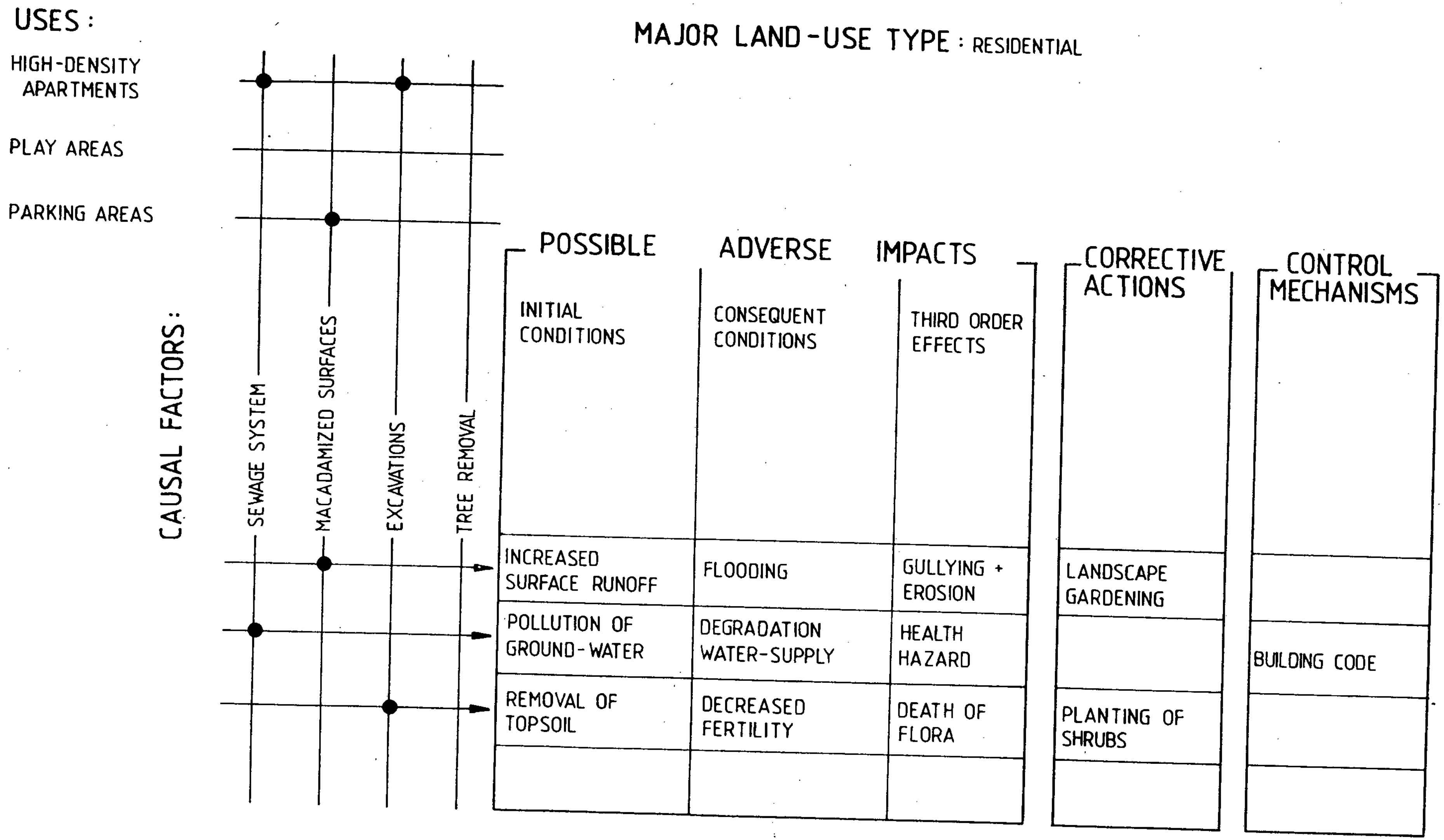


FIGURE A.6 Example of Sorensen Network (from Sorensen, 1971)

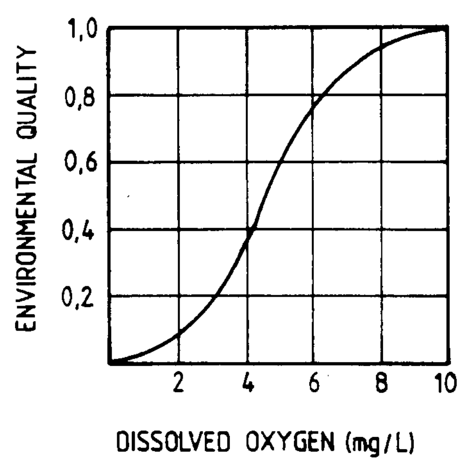
Special Methods

A number of Environmental Impact Assessment methods have been developed to accomplish more sophisticated evaluations, and some of these might be regarded as specialized decision making models. These methods are usually designed to evaluate a specific type of development, such as water storage projects, in a special type of environment, such as wetlands or areas suitable for water impoundments. Examples are Adaptive Environmental Assessment and Management, Environmental Evaluation System, Environmental Quality Assessment, Environmental Quality Evaluation Procedure, Habitat Evaluation Procedure, Surrogate Worth Trade-off Method, Water Resources Assessment Method, and Wetland Evaluation System (Bisset, 1987). Two of these methods are briefly described in what follows.

The Environmental Evaluation System

The Environmental Evaluation System (Dee *et al.*, 1973) was developed to evaluate major water storage projects. This method involves measuring forecast changes to specific environmental parameters, determining the significance of these changes, and evaluating the ultimate social value of the project. In developing the method, experts were asked to generate graphs for use in the field to measure the degree to which a project might cause key environmental parameters to change; the graphs purport to depict the relationship between these changes and changes in environmental quality. In addition, a group of respected persons were asked to apply the Delphi method (see Delphi and Nominal Group Technique in Chapter 3) to determine the relative importance of each of the selected parameters.

This information is used by field researchers to evaluate specific projects: by multiplying the predicted change in the quality of each environmental parameter by the importance of that parameter, and then summing the products over all the parameters, the ultimate effect of a project on environmental quality can be determined and compared to that of another project. Figure A.7 presents an example of how a forecast change in an environmental parameter is expressed in terms of environmental quality units. For example, if it is predicted that a project will reduce dissolved oxygen concentration to 6 mg/l, then the graph indicates that this will result in a score (expressed in environmental quality units) of 0,7. Since the evaluation panel mentioned above had previously determined that the importance of this parameter is 31 parameter importance units, it is possible to calculate the "value" of the impact: 21.7 environmental impact units (Fuggle, 1983:498-499).



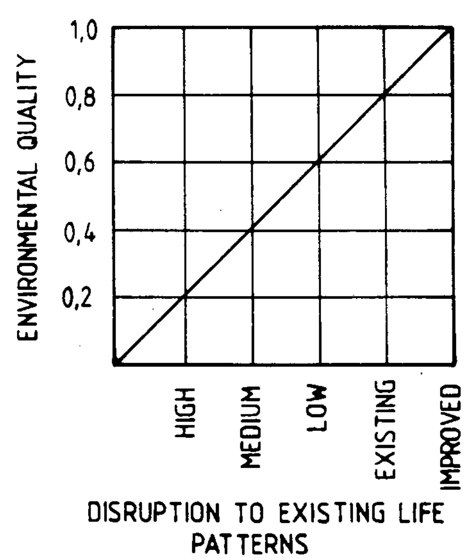


FIGURE A.7 **Example of Environmental Parameter Graphs (from Dee <u>et. al.</u>, 1973)**

A major difficulty with the Environmental Evaluation System is that it is questionable whether the relative importance of a set of abstract parameters can be determined, or whether such measures have any real meaning or validity in a particular case. Firstly, it is extremely difficult to even conceptualise an environmental parameter or characteristic, much less value it, without reference to some specific set of circumstances with which it can be associated. Secondly, valuation of the change to a particular parameter can vary a great deal from case to case depending on a number of variables. Dalkey *et al.* (1972), for example, found in one experiment that respondents gave a high desirability rating to train travel as a general mode of transportation, but a low rating to train travel in particular situations. This indicates that valuation, to be meaningful, requires a specific situational context.

The Sondheim Method

Sondheim (1978) also developed a method of evaluating water development projects, although his method can easily be adapted to any environmental evaluation problem. The Sondheim Method uses two multidisciplinary panels to accomplish a systematic evaluation of a large number of alternatives. The panels are asked to evaluate the relative environmental value of "m" alternatives, with the environment defined as a function of "n" aspects.

First a "rating panel", comprised of specialists from a number of disciplines, judges each alternative project in terms of each aspect, assigning scores using either an interval or ratio scale to produce "n" rating schemes. (The Delphi method or some other method can be used by each team to produce a rating scheme for each aspect; scales are later normalized.) Table A.1 presents an example of how several alternatives might be judged in terms of different aspects.

TABLE A.1
Examples of Rating and Weighting from Sondheim

Rating Panel Comprised of Experts

Aspects	Alternative proposals			
	1	2	3	4
Ecological Diversity	75	15	90	5
Benefit/Cost Ratio	1:1	1:3	2:1	1:1

Weighting Panel Comprised of Affected Parties

Panel Member	ASPECTS				
	Ecology	Economics	History	Aesthetics	Physical
1	16	5	10	20	1
2	0,2	0,8	0,1	0,0	0,4

Next a "weighting panel", comprised of affected or interested parties, evaluates each aspect on an interval or ratio scale to produce "n" weighting schemes. (Again, panelists are free to use any weighting scheme.) Table A.1 also presents an example of how several aspects might be judged by different panelists.

Then a project coordinator normalizes the rating scheme scores, multiplies these by the scores of each weighting scheme, and standardizes the results (so that the weightings of each member are equal). The alternatives can then be ranked according to their overall performance in respect of the various aspects.

The Sondheim Method shares a general weakness of the Environmental Evaluation System: abstract aspects (pertaining to, for example, ecology, economics, or aesthetics) are weighted relative to other abstract aspects, which is difficult and of questionable relevance for the reasons given above. What would be preferable is a direct weighting of the relative importance of changes to aspects, and a way of summing the values of these changes to obtain a net value for each alternative.

APPENDIX B

THE REQUIREMENTS OF AN ENVIRONMENTAL EVALUATION METHODOLOGY

The central object of a general environmental evaluation methodology (or any specific method of environmental evaluation) is to provide a systematic, reliable and satisfying means for determining which of two or more alternative resource allocation proposals would best satisfy specified evaluation criteria. The formulation and adoption of a comprehensive evaluation methodology would serve to ensure a professional analysis of society's diverse and conflicting needs, improve the quality of proposed actions, reduce the arbitrary nature of resource allocation decisions, and replace casual, purely intuitive evaluations of the potential effects of proposed actions on social well-being with more carefully reasoned and explicit evaluations.

Environmental evaluations have been traditionally accomplished with the aid of Environmental Impact Assessment methods and techniques. Several sets of criteria have been suggested for evaluating the potential of Environmental Impact Assessment methods, and it is generally agreed that none have met all the criteria that have been specified (Bisset, 1980, 1987; Clark *et al.*, 1978; Haug *et al.*, 1984a; Hollick, 1981a, 1986; Lee, 1982; Warner and Preston, 1974). An environmental evaluation methodology should obviously satisfy all assessment criteria, but special attention must be given to the two principal evaluation problems: (1) judging the significance of impacts, and (2) making trade-offs between competing objectives. This appendix presents a discussion of these and other requirements that might be stipulated for any environmental evaluation methodology.

An environmental evaluation methodology should provide practical analytical procedures for identifying all the issues of possible importance, forecasting possible outcomes, clearly describing and evaluating these outcomes, and evaluating their significance to specific groups and to society as a whole. Procedures should also be devised to evaluate the relative worth of competing objectives, or combinations of objectives, for any resource allocation activity, and these procedures should be capable of providing meaningful results in situations where data are limited (Blackie, 1980:5-6; 1981).

Although many people believe that it is not possible to obtain sufficiently reliable measures of the social significance of environmental impacts to unambiguously determine whether benefits outweigh costs, or to unambiguously rank alternative proposals according to their overall social value, environmental evaluations by their very nature require that some attempt be made to do this. Every effort should therefore be made to develop <u>improved</u> procedures for measuring subjective value judgments, and thus to provide more reliable guidance for making resource allocation decisions. There is a need to reshape analytical and institutional devices to address more directly the kinds of value uncertainties and conflicts that face modern society, such as the comparing of "hard" values (*e.g.*, improvements in the standard of living) with "soft" values (*e.g.*, ecological stability, love of natural beauty) (Tribe *et al.*, 1976:x-xii). The challenge is to bring all values into a common intellectual framework for analysis (Brooks, 1976:116).

A general environmental evaluation methodology for improving resource allocation decisions should be comprehensive in scope, systematic in its approach, and open to public scrutiny and debate. If there is likely to be considerable uncertainty or controversy as to the merits of a proposal, then the methodology should provide an acceptable procedure for making subjective value judgments explicit. It should also be capable of being applied to any resource allocation problem under any set of monetary, manpower or time constraints, and have the flexibility to incorporate within its general framework a full range of valuation techniques in order to make it cost-effective in any particular application.

The methodology should be adaptive and capable of adjusting to unfolding developments (such as the discovery of new information, revised objectives or a change in priorities); it should also be capable of evaluating national, long-term and general resource allocation projects, programmes and policies, as well as local, short-term and specific proposals (Clark *et al.*, 1978:120). Of special concern is the ability to evaluate long-term, cumulative and synergistic effects of proposed actions. This is of growing importance, given society's new environmental predicament, in which regional and even global ecosystems are being disrupted, and the rate, scale and complexity of impacts to both biophysical and socioeconomic systems are rapidly increasing (Allen, 1980; Clark, 1989; International Union for the Conservation of Nature, 1980; Global 2000 Report, 1980).

A general methodology should be concerned with guiding the decision maker in evaluating complex, hard-to-manage problems by dividing them into smaller, more manageable problems, and then synthesizing the separate analyses in an acceptable way (Easton, 1973:x). The methodology should be capable of taking into account the attitudes of decision makers toward risk and uncertainty, yet it should not make great demands on the decision maker's time, or require frequent access and substantial interaction with the decision maker, since most decision makers are busy people with little interest in being intimately involved in every step of the evaluation process.

Special provision should be made for involving other people, to include:

- experts from different disciplines;
- authorities with responsibilities for or special knowledge relevant to the particular proposal;
- special-interest groups; and
- all potentially affected or concerned parties.

Emphasis should be placed on finding compromise solutions to resource allocation conflicts, and achieving consensus on major issues. But even if the controversy cannot be resolved, the active participation of all these groups is important because it will ensure that all potential impacts are identified and clearly understood, so that investigations will be cost-effective and the analysis will be relevant. A concerted effort to obtain many points of view and seek out expert opinion will also reassure and satisfy the various publics that all issues of possible concern will be thoroughly investigated and adequately evaluated.

Perhaps the most important consideration is that the methodology should be seen to be relevant and useful in providing guidance for improving resource allocation decisions; therefore, the assumptions on which it is based, and the results it produces, must meet the test of reasonableness (Foster, 1978:86), and all aspects of the methodology must be conceptually acceptable to decision makers and their constituencies.

An environmental evaluation methodology for addressing resource allocation problems must incorporate both planning and assessment functions: viable alternatives must first be identified by some rational and cost-effective process, and then the implications of these alternatives (in terms of their impacts on biophysical and socioeconomic systems) must be adequately assessed to provide information for determining which alternative is in the best overall interests of society. This assessment must not be too late in the development process to influence plans and development decisions, and ideally there should be a positive, interactive and iterative link between the assessment and planning stages of any development so that plans can be improved or refined by constructive input from formal assessment (see The Concept of Integrated Environmental Management in Chapter 4).

A particularly daunting task that would improve the usefulness of environmental evaluations is to develop acceptable weighting and trade-off procedures to estimate more accurately the relative importance of different outcomes, criteria and alternatives. While a general methodology of resource allocation should be primarily directed at guiding the planning and decision making process, rather than searching for an elusive "optimal solution" (Bisset, 1980; Lee, 1982; Hollick, 1981b, 1986), it should also - to the extent possible - make use of quantitative techniques to more accurately and reliably judge the relative value of outcomes, make trade-offs between objectives clear and explicit, provide systematic and rigorous comparisons of competing alternatives, and avoid arbitrary, unsubstantiated conclusions (McAllister, 1980:184). Nevertheless, since the principal object of any evaluation is to make qualitative judgments and to form an holistic impression of trade-offs and the relative worth of competing plans, there should be no reliance on a "grand index" or final number which is intended in itself to indicate the optimal action (McAllister, 1980:265).

Complex methods which rely on abstruse evaluation techniques and the calculation of a single numerical result are not likely to be politically acceptable; most decision makers are dubious about and not satisfied with a "bottom-line number", but want a "picture" of the major alternatives, and this requires a method which provides descriptive, qualitative and disaggregated information (Bisset, 1980:27). Purely quantitative methods are playing a decreasing role in Environmental Impact Assessment because the practice of aggregating scores masks much of the analysis and leaves little to the judgment of decision makers (McAllister, 1980:37-38, 41). Also, such methods tend to present decision makers with a *fait accompli*, and it is possible the data have been manipulated to reach a preconceived conclusion (Clark *et al.*, 1978:120). All quantitative assessments must therefore be clearly explained, so there is no question how the numbers were arrived at and what they mean, and numerical evaluations should not dominate the analysis, but play a supporting role. Ribe (1982:69) has pointed out the usefulness of numbers as a powerful means of rigorously describing, testing and analyzing relationships in ways not possible through the use of only qualitative concepts and descriptions; yet, a quality labelled with a number is no less a quality, and those qualities should be the essential content of any assessment or evaluation method.

The methodology should be simple, straightforward, and appealing, and be seen to assist rather than force the practitioner to follow a logical approach to evaluation. Many formal methodologies are characterized by excessive, inbuilt rigidities which render them less acceptable to decision makers because the emphasis on procedural compliance is regarded as laborious, obfuscating, and wasteful. There is no need to adhere to a complex, circuitous, tortuous algorithm when the human brain is capable of making great leaps and focusing on what is truly relevant (Massam, 1980:29). Thus, while the methodology should be based on sound principles of rational analysis and follow a logical set of procedures, it should also consciously make provision for accommodating intuition and special insight. In the final analysis, superior decisions will result from the exercise of sound personal judgment more than from following a rigid set of standardized procedures (McAllister, 1980:x), and analytical procedures should be viewed as a guide to clear thinking, not as a substitute.

The principal characteristics of a desirable research methodology for environmental evaluation may be summed up as follows:

The ideal methodology would

- provide a systematic approach to planning, assessment and decision making
- be comprehensive so that all potentially relevant aspects will be considered
- be applicable to all conceivable types of resource allocation problems, and practical to implement in a wide variety of situations
- direct attention to the real issues
- simplify without distorting the decision making problem
- make use of intuitive reasoning but be primarily guided by principles of rational thinking

- include methods developed in accordance with principles of economic rationality, but be based on principles of political rationality and capable of adapting resource allocation strategies to changing circumstances

- be capable of using a wide range of investigative and evaluative techniques and using input from a variety of sources (*e.g.*, consumers, experts, decision makers)

- consider the needs of all potentially affected or concerned groups

- provide opportunities for individuals to make their concerns known and contribute other useful information

- generate and identify the most promising alternatives

- apply acceptable techniques for forecasting, assessing and evaluating the possible outcomes of the most promising alternatives

- be principally concerned with finding compromise solutions or alternatives that will satisfy all contending parties and so achieve a broad and democratic consensus on the action to be taken

- provide, when a compromise solution is not possible, a set of procedures for resolving conflicts that are acceptable to all contending parties

- be capable of factoring in attitudes toward risk and uncertainty

- require, when proposals are especially controversial, that subjective value judgments are made explicit, and ensure that the reasoning underpinning these judgments is clearly explained

- make use of acceptable weighting and scaling techniques to evaluate the relative importance of outcomes and alternatives

- be capable of handling multiple objectives and making trade-offs when there are mutually-exclusive alternatives and no alternative is superior in terms of all the evaluation criteria

- ensure that the entire evaluation and decision making process is rational, clear and open to public scrutiny.

The principal advantage of adopting a formal methodology for evaluating environmental resource allocation options may lie more in the types of questions that its utilisation generates than the kinds of answers it provides (Green and Tull, 1978:56). Even though application of the methodology may not provide infallible results, or ensure the identification of the best option, it forces one to think along the right lines (Gregory, 1979:22). Of special importance is the value of forcing planners, analysts and decision makers to examine assumptions and make subjective value judgments explicit: subjective data can be far more relevant to the decision than objective data (U.S. Army Engineers, 1975:53), and an evaluation methodology should ensure that underlying beliefs, attitudes, opinions and values are carefully examined and used explicitly to make and justify choices.

APPENDIX C

THE CHALLENGE OF DEVELOPING A FORMAL METHOD OF EVALUATION FOR CONTROVERSIAL RESOURCE ALLOCATION PROPOSALS

The Need for a Formal Evaluation Method

A major problem in resolving value conflicts is the breakdown of discourse. Adopting clear and acceptable evaluation procedures and decision rules for selecting the preferred alternative would establish trust, open up communication and serve to substantially reduce the conflict between competing interest groups, who are always suspicious that parties with the power and knowledge to do so will use subversive methods to influence the decision. A major reason for the extreme controversy which often develops around environmental issues, and the emotionally-charged arguments by extremist groups on both sides, is the absence of a trusted, rational approach to investigating the relative merits of different proposals, and in particular the absence of a formal evaluation method to which all parties can subscribe.

Conservationists, for example, have tended to adopt uncompromising stands or absolutist positions largely to avoid the "thin-edge-of-the-wedge" effect, because nonquantifiable values are easier to defend in absolute terms than in a utilitarian framework (Kneese and Schulze, 1985). But this "passionate advocacy" approach leads to radical, indefensible positions which eventually renders the absolutist strategy ineffective, or even counter-productive, and is in any case extremely costly for all concerned (Gardiner and Edwards, 1975). By the same token, many developers and public authorities feel they must rely on subterfuge or political influence to counteract the "conservationist" strategy. But this generates cynicism amongst the general public and fosters a truculent, uncompromising attitude which often leads to litigation or the loss of constituencies.

In the case of controversial resource allocation proposals, a widely-accepted method for evaluating qualitative data and making trade-offs between competing resource allocation objectives would reduce the incentive to take extreme positions and the tendency to rely on emotive arguments or devious tactics. This would in turn make possible improved communication, and stimulate a meaningful exchange between different groups in order to explore the issues in a more rational manner. Both sides would then be encouraged to develop specific and truly convincing arguments as to how, and how much, a proposed development would hurt or benefit society in both the short- and long-term. The final result would be a more effective evaluation, and better decisions.

Adoption of a clearly-defined and acceptable process for resolving conflicts pertaining to the management and disposition of environmental resources would also lend greater public confidence in the wisdom and justice of the political and administrative functions of government. There is now in South Africa a pervasive perception that important resource allocation decisions are often made for political or personal advantage, that the decision making process is too unsystematic and hidden from public scrutiny, and that decisions are based on *ad hoc* and secret appraisals which utilise unreliable methods that often produce spurious results (Louw and Kendall, 1986). Public confidence is thus undermined, and citizens feel impotent and abused.

A completely open approach to environmental evaluation, which involves a set of procedures seen to be impartial, comprehensive, systematic, clear and rational, would demonstrate the competence and good faith of decision makers. If the evaluation method is structured and formalized, and uses understandable and reliable techniques for identifying and measuring all impacts, and satisfactorily treating value judgments which are generally regarded as being nonquantifiable, there will be greater public acceptance of the resulting decisions. Utilization of the method will make it easier for the decision maker to explain and justify his decision, will remove political "heat" from the decision maker, and will lead to a better understanding of and appreciation for the political decision making process.

Before the challenge of developing a formal evaluation procedure can be addressed, it is necessary to consider in more detail the nature of the resource allocation decision, and especially the relationship between evaluation and decision making. This is the subject of the next section.

The Importance of Clearly Defining Goals, Criteria and Decision Rules

The first step toward developing a formal method of evaluation is to obtain absolute clarity as to exactly what is required, and why. Resource decision making (like all other kinds of decision making) involves three major processes (whether performed consciously or unconsciously) which are closely interrelated:

- defining goals, objectives and constraints
- gathering information
- evaluating that information and applying a set of decision rules.

The major challenge in resource allocation is to adopt a rational approach for gathering and evaluating information, and to apply a logical set of decision rules to judgments made during the evaluation process, that will be acceptable to all concerned parties. This is particularly important in the case of controversial resource allocation proposals. There are three considerations which are relevant to this challenge:

- First, the decision maker needs to be clear as to what his goals, objectives and priorities are, the constraints under which he is operating, and the administrative procedures and mechanisms that have been established for processing information.
- Then, for each case, the decision maker requires a reasonable amount of information about the possible alternative uses of the resources in question, and the effects that each of these uses would have on the populations of interest.
- Finally, the decision maker must adopt an acceptable procedure for evaluating this information in the light of his goals, objectives, priorities and constraints, and apply some reasonable set of decision rules in the course of the evaluation process in order to arrive at a decision.

This is a complex and iterative process. For example, it is obviously desirable to reduce uncertainty, but the question is by how much? Decisions are often changed in the light of new information, and one type of decision that may be changed several times is that concerning how much information should be obtained, and at what cost. This decision depends, among other things, on an evaluation (whether implicit or explicit) of the importance of the information to the ultimate decision and, of course, some evaluation of the importance of the ultimate decision itself (Coyle, 1972).

Just as complex, and perhaps even more important, is the problem of estimating the value, utility or significance of forecast outcomes, examining preferences and applying multiple criteria (Bell *et al.*, 1977; Easton, 1973; Fardel and Gal, 1980; Keeney and Raiffa, 1976; U.S. Water Resources Council, 1980). Every decision involves subjective value judgments about the meaning of forecast outcomes, and almost every decision involves making compromises between competing objectives, or between objectives which cannot be maximized simultaneously.

As stated earlier, the appropriate approach to decision making in specific cases will largely depend on whether the proposal is expected to be controversial or noncontroversial. For noncontroversial proposals the problem is essentially one of how to conduct an effective bargaining process and discover compromise solutions that will resolve conflicts. In such cases, there is no need to make provision for formal evaluation procedures; what is needed instead are effective negotiating procedures.

For controversial proposals, however, negotiations are likely to be unproductive, and informal evaluations will not generally suffice because some of the contending parties will mistrust what they see as relatively casual, narrow or biased evaluations performed by planners, analysts and decision makers. For these proposals, therefore, there is a need to ensure that all realistic options are considered, employing a logical process, in which forecasts and value judgments are explicitly stated so that the reasoning which leads to specific choices can be followed. The principal object of adopting such an approach is to ensure that the right questions are being asked and considered in the right way, even if there may be great disagreement over the possible answers.

Resource allocation problems in general, and controversial resource allocation problems in particular, are complex problems to formulate and analyze. Even after they have been formulated and analyzed, they still present difficult problems of choice for the decision maker. Some of the questions to be addressed are:

- What are the various outputs that are obtainable from a given set of resources?
- How can each of the possible outputs be obtained with the minimum expenditure of resources?
- What is the relative value of these outputs to society, and how can this be measured?
- Who will receive the benefits associated with the outputs, and who will bear the costs?
- When will the benefits be received, and when will the costs be borne?

In order to answer these questions, it is necessary to address a host of more specific questions pertaining to technological, social, economic, and environmental considerations. Very often it is only these more specific questions that get asked at all, and then sometimes only the technological and economic questions.

But before any of the above questions are addressed, it is necessary to first ask a very simple but fundamental question: What is the goal of resource allocation? It is surprising how seldom this question is asked or clearly answered. Many analysts and decision makers apparently feel that the answer is all too obvious - they may believe they have an adequate understanding and appreciation of what the answer is, an intuitive sense of what they are trying to accomplish, and so it appears unnecessary to formally express the goal. Others apparently feel that the goal is too complex to define, or that any goal statement would only generate controversy and make their job more difficult.

Yet formally stating a goal is a crucial task, because it forces one to make one's assumptions clear and reveal the premises that underlie the approach to planning, analysis and decision making that is to be adopted. Often the exercise will lead the planner, analyst or decision maker to question his assumptions and premises, or expand his thinking to embrace new objectives, with the result that a whole new approach to the problem is adopted. A formal goal statement will also communicate to interested publics the basis for the decision, and obviate misunderstandings which are often at the root of the public controversy over resource allocation decisions.

Once the goal of resource allocation is formally stated, specific objectives can be adopted and criteria can be selected by which progress toward the goal can be measured (see Defining Evaluation Criteria in Chapter 4). Evaluation procedures can then be devised for measuring progress, making trade-offs, and otherwise applying the criteria.

Considerations in Developing Formal Evaluation Procedures

Formal evaluation procedures must be acceptable to all concerned if they are to be truly useful. Whenever there are scientific uncertainties, conflicting expert opinion, differences in attitudes toward risk and uncertainty, differences in beliefs and values, a feeling that important costs and benefits are incommensurable, and a perception that the subjective value judgments or hidden agendas of a few people might be arbitrarily imposed on others, it is particularly important that the procedures for comparing and evaluating alternatives be seen as fair and open to all interested parties.

But in order to be acceptable, it is not necessary to demonstrate that evaluation procedures are totally infallible, or capable of producing absolutely precise or perfectly replicable results. Even if measurements of value cannot yet be made with absolute accuracy, and are not perfectly reliable, value information is still of central and paramount importance to any rational assessment of resource allocation alternatives. An examination of values, feelings, and beliefs is essential if one is to proceed with what information is available and make decisions on the allocation of resources (Matthews, 1975). Objective determinants and indicators of well-being appear to have limited efficacy in providing relevant information for resource allocation decisions, and the challenge is to find a reasonably trustworthy method for treating qualitative data and revealing subjective judgments in a way that is as objective as possible (Campbell, 1976; Deane and Mumpower, 1977; Finsterbusch, 1977a, 1977b; Hollick, 1981a).

In fact, reliance on objective data to guide resource allocation is no assurance of objectivity. Miller (1985) has pointed out that the prevalence of psychological biases in environmental problem-solving and decision making suggests that the notion of objective judgment is an illusion. Biases operating at a covert level often lead to conflict over the interpretation of data or the formulation of the problem at hand.

There is simply no escaping the necessity of allowing subjective data to play the central role in evaluations of resource allocation proposals: even objective determinations have to be made within the context of subjectively-chosen parameters (Matthews, 1975:124). Yet there is still a great reluctance on the part of many analysts and decision makers to recognize and accept the crucial importance of relying on subjective data. This reluctance is no doubt due to the inherent difficulty in dealing with subjective data, and to the fact that it is not possible to use subjective data to reach conclusions which will be safe from reproach. In spite of such reservations, intelligent decisions directed at improving social well-being cannot ignore or de-emphasize these data; as Price (1977:96) has said, fastidious abstention from subjectivity is an unacceptable form of self-indulgence.

The important thing is to ensure that subjective data are always treated in a systematic manner, and that all judgments based on such data are made completely explicit (Westman, 1985). The object of the evaluation, after all, is not to generate irrefutable facts to prove some hypothesis, but to provide convincing evidence for deciding which resource use seems to have the superior claim. Policy requires the making of decisions and not the calculation of values as such; if we cannot identify the optimal decision, we can at least search for improved decisions (Sinden and Worrell, 1979). Subjective judgments are adequate to the extent that they can be shared and are convincing; and these conditions tend to be met only to the extent that estimation procedures tend to be explicit and logical and plausible, if not objective (Mitchell *et al.*, 1975:43).

The Problem of Valuation

The most crucial and difficult task in a formal evaluation, and the first one that must be addressed, is how can one determine the relative significance of a list of outcomes so that one can apply evaluation criteria in a more meaningful way? The central difficulty with evaluating the social consequences of actions is that individuals can be expected to place different valuations on the same outcome, and there is no "true" or "correct" valuation. Evaluation is, by its very nature, subjective, and no universally acceptable set of decision rules exists for reconciling differences of opinion that arise when judging the relative value of different outcomes.

Even market valuations, which consist of monetary measures of the relative value of unlike goods, only apply to those goods in which private property rights can be specified and satisfactory exchange mechanisms exist; furthermore, market prices do not accurately indicate the true social value of such goods because there are many imperfections in the market which render these valuations suspect (Common, 1988; Dohan, 1977; Pearce, 1983; Rees, 1985). Monetary measures of value should not, therefore, be regarded as sacrosanct, and other methods of measuring value may be adopted so long as their shortcomings are also recognized and accepted (see Chapter 3).

Environmental evaluation is still more of an art than a science, and measurements of the value or significance of environmental impacts tend to be, when compared with other scientific measurements, rather crude and unmethodical. Of particular concern is the fact that the evaluation process in most Environmental Impact Assessments is not clearly explained: outcomes are said to be "significant" (*i.e.*, have special meaning or value), but there is generally no attempt to accurately convey a measure of that significance. In fact, many impact reports make frequent use of the term "significant" without communicating what is meant by this term, and without providing any explanation of how significance determinations - the "weighing" of information in environmental evaluation (McAllister, 1980:3) - have been made, in spite of the obvious and central importance of the concept in environmental assessment (Duinker and Beanlands, 1986:1). This is important because the arguments at the heart of most controversial resource allocation proposals revolve around claims about the relative significance of impacts.

In order to conduct a formal evaluation of controversial resource allocation proposals, it is necessary to adopt some mechanism for measuring the relative significance of impacts. Very often the only attempt to do this is to give some indication of the magnitude of the impact. Measures of magnitude do often improve significance judgments, but can be misleading and are only part of the information that is necessary to make the significance determination. In fact, a simple qualitative description of an impact can sometimes provide sufficient information to make a subjective determination of the relative importance or social significance of that impact compared to other impacts.

A major reason for the failure of so many Environmental Impact Assessments to use formal methods of evaluation, and for the dissatisfaction with those methods that are being used, is the difficulty in addressing the problems of defining and measuring significance. While some practitioners have attempted to deal with these problems (Cheney and Schleicher, 1982; Conover *et al.*, 1985; Haug, 1984b; Khorramshahgol and Moustakis, 1988; Lee, 1982; Prasartseree, 1982), there is as yet no indication that the problems have been satisfactorily resolved. What is needed is a clear understanding of what constitutes significance, and some way of relating the significance of one impact to that of another.

The Problem of Defining Significance

To say that an impact will be significant is to suggest that it will be a matter of great concern to some members of society. But this is bound to be a subjective judgment: there are no objective, verifiable thresholds beyond which an action becomes socially significant. Judgments as to what constitutes a significant impact require considerations of both context and intensity (U.S. Council on Environmental Quality, 1978:31).

Context has both a spatial dimension and a time dimension. An action may not be significant on a national level, but may be regarded as quite significant on a regional or local level. Similarly, an action may not seem particularly significant in the short term, but the long-term implications may be regarded as significant. For example, the loss of a local resource may not significantly affect the present national interest or level of welfare, but local residents or future generations may be profoundly affected by this loss.

Intensity refers to the severity of the impact resulting from an action, as judged either by some knowledgeable authority or by the people affected by the impact. If reputable persons with special knowledge or experience believe the impact will be significant, then it should be so regarded. Similarly, if those who will bear the impact genuinely believe that it will significantly affect their well-being, or if the action is highly controversial, then the action should be regarded as a significant one. Considerations of intensity would include, among other things:

- the degree to which the proposed action affects public health or safety;
- the degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks;
- the degree to which the action or impact is irreversible;
- the degree to which the action affects the availability or functioning of life support systems, natural amenities, cultural resources and other environmental goods, services and conditions which are considered to be of a special or unique character, in limited supply, and/or essentially irreplaceable;
- the degree to which the action violates the spirit or the letter of any law or statute;
- the degree to which the action may establish a precedent for future actions with significant effects, or represents a decision in principle about an issue with significant implications; and
- the degree to which the action is related to other actions or proposed actions which individually may have insignificant impacts but which cumulatively could result in significant impacts.

The Problem of Measuring Significance

The principal difficulty in evaluating controversial proposals is to find an acceptable means of measuring the value or significance of impacts - particularly those which are not normally thought of in monetary terms. The resolution of conflict amongst competing demands for resource usage depends on the provision of strong evidence to back up claims about the value or "utility" to be derived from each resource use.

Ideally, the utility of each potential output would be measured in an objective manner. Objective judgments are those which involve or use facts that are observable or verifiable, whereas subjective judgments are those which are made on the basis of values, feelings, and beliefs (Matthews, 1975:121). The scientist's principle criteria of objectivity are validity and reliability: to be objective, a measurement must be demonstrably accurate or true, and capable of being replicated. But the utility of a thing, being subjective in nature, cannot be directly observed so that its magnitude can be verified; it would appear, therefore, that the concept of utility would defy accurate and reliable measurement.

In fact, the classical theory of demand in the science of economics was modified because it was determined that utility is essentially a psychological concept which is incapable of direct measurement in absolute units. Demand theory was therefore recast in terms of ordinal utility; then it was possible to measure utility in a less rigorous manner (on an ordinal scale) using indifference analysis, which only requires the consumer to rank quantities of goods on the basis of preference or indifference (Bannock *et al.*, 1978:449-450). This is held to have put demand theory on a much sounder footing, and despite developments in decision theory almost all economists and other scientists would probably still agree that there is no way to obtain accurate and reliable measures of utility (or value) on an interval or cardinal scale (Alchian, 1953).

Not all scientists have given up though. Von Neumann and Morgenstern (1964:17), in developing their theory of games, point out that a breakthrough may still be possible.

> The historical development of the theory of heat indicates that one must be extremely careful in making negative assertions about any concept with the claim to finality. Even if utilities look very unnumerical today, the history of the

experience of heat may repeat itself.... it should certainly not discourage theoretical explanations of the formal possibilities of a numerical utility.

The Problem of Scaling Subjective Value Judgments

As has been indicated in Appendix A (which discusses the historical development of environmental evaluation), the U.S. National Environmental Policy Act of 1969 recognized the fundamental importance of developing some suitable means of evaluating the significance of actions and potential impacts; in fact the requirement to prepare an Environmental Impact Statement was to be based on a judgment as to whether an action could significantly affect the quality of the human environment (United States, 1969:Sec102[C]). But the National Environmental Policy Act does not give any guidance as to how to judge the significance of an action or an impact, and simply calls for the development of new methods and techniques for evaluating significance.

In determining what actions should be subjected to the provisions of the Environmental Impact Statement process, and in deciding whether and under what conditions certain actions should be allowed, it is necessary for some person or group of persons to make a value judgment concerning the action or impacts. This vitally important process has usually been conducted in an unsystematic manner, without any requirement for making subjective value judgments explicit. Even when such measurements are systematic and explicit, the approach taken is often not sound. For example, in many cases the evaluation is undertaken by persons whose value systems may not be acceptable (because they are not representative of or respected by the concerned parties). This is a major weakness with matrix and overlay methods, in which analysts or planners are asked to determine the significance or value of data (see Appendix A). Several decision making methods, such as Decision Analysis and Linear Programming, also share this shortcoming (Bowes and Krutilla, 1985; Coyle, 1972; Edwards, 1967; Raiffa, 1968; Simon, 1978).

In other cases, the measurement procedure is flawed because what is being measured is an abstract entity rather than a change in utility. In conducting an evaluation, it is important that significance judgments are not made in a vacuum; there appears to be no way to measure the significance of a thing without comparing it to the significance of another thing in a specific context. In addition, the more abstract the things being evaluated, the more difficult it is to conceptualize their relative values. This was a major failing of the Environmental Evaluation System (see Appendix A). In this method of evaluating proposed water resource development projects, one of the principal tasks was to ask a group of individuals to judge the relative significance of such abstract parameters as water quality and species diversity. This is difficult to do outside the context of a specific set of circumstances, and in fact what is of importance in environmental evaluation is neither the absolute nor the relative value of abstract entities, but rather the amount of change to particular elements in a given situation. For example, in one situation a small change in water quality could be of much greater significance than a large change in species diversity, whereas in another situation the opposite could be the case. The relative significance of water quality and species diversity cannot be predetermined out of context, and cannot be calculated with any fixed formula relating either abstract qualities or measures of magnitude to importance.

Another common example of a flawed measurement procedure is the case in which the judgments of several people are aggregated even though the data do not meet the requirements for this mathematical operation (see Primary Types of Measurement Scales in Chapter 3). In fact, the central problem in evaluating the significance of unpriced impacts is that there is no objective scale of measurement, and therefore the judgments of two or more people are not commensurate. There are two possible solutions to this problem:

- either all concerned parties must agree that one person's judgments are superiour to those of all other persons, or

- some means must be found to obtain and aggregate the honest and impartial judgments of a number of persons whose combined judgment will be respected by all concerned parties.

If the first solution is acceptable to the major parties in a resource allocation dispute, the person whose judgments are esteemed can simply be asked to conduct the evaluation and resolve the issue. In this case, commensurability is not a problem. But if this approach is not acceptable to one or more of the major concerned parties, and the second solution must be adopted, then it is necessary to find an acceptable way to aggregate the subjective value judgments of several individuals.

There are two difficulties in aggregating the subjective weightings of two or more people (Linstone and Turoff, 1975:580):

- there is no true zero point to which measurements by different individuals can be related ("the problem of subjective origins"); and

- there is no common unit of measurement utilized by different individuals ("the problem of subjective scale units").

If neither the zero point nor the unit of a utility scale can be objectively determined, value judgments by different people cannot be compared. Therefore, in order to combine the evaluations of several people, a technique is needed that will allow individual evaluations of significance to be adjusted to a standard origin and converted to uniform scale units. If it is possible to satisfactorily approximate a zero point, and to bring different units of measurement into a common relation, subjective weightings by different individuals can be aggregated and otherwise manipulated mathematically. A technique has been developed and tested in the course of this research which, it is claimed, produces results that meet a reasonable standard of replicability and provides a credible approach for evaluating controversial resource allocation proposals (see Impact Evaluation in Chapter 5).

APPENDIX D

FORMAL EVALUATIONS BASED ON THE DECISION MAKER'S JUDGMENTS

Several formal methods have been developed to aid decision making, and this appendix is intended to give some indication of the general approach that has been used to assist the decision maker in undertaking a rational evaluation. These methods are directed at guiding the decision maker through a series of steps (usually with the aid of an analyst, and often involving computer-assisted mathematical operations and modeling) which will ultimately reveal the best course of action. The procedures used are intended to elicit explicit judgments both as to the consequences of alternative proposals and the relative importance of those consequences. The focus is on Decision Analysis, which is the archetype of this class of methods.

Decision Analysis

Oftentimes the decision maker will prefer to conduct his own evaluation of the alternatives, rather than to have other parties accomplish an independent evaluation. This may not be acceptable to some of the affected parties since the decision maker's knowledge, attitudes, opinions and values may be perceived as limited or differing significantly from their own, and they may not wish to completely rely on the decision maker's subjective interpretations of the available data. But if a broader evaluation is not possible or not particularly wanted, the decision maker would be well advised to adopt some rational procedure to guide the evaluation process. Decision Analysis is one such procedure.

General Description

Decision Analysis (Bakus *et al.*, 1982; Baumol, 1972; Bisset, 1980; Coyle, 1972; Edwards, 1967, 1977; Fischhoff *et al.*, 1982; Green and Tull, 1978; Hershey *et al.*, 1982; House, 1980; Kassouf, 1970; Keeney and Raiffa, 1976; Miller and Ladd, 1984; Raiffa, 1968; Sinden and Worrell, 1979) is one of a family of methods which Raiffa (1968) groups under Operations Analysis. Others in this family include: Operations Research; Management Science; Decision Science; Cost-benefit Analysis; Cost-effectiveness Analysis; Planning, Programming and Budgeting; Optimal Allocation; Decision and Control; and Systems Analysis (Raiffa, 1968:295). These methods are all concerned with dictating how one ought to behave in complex situations, and particularly how to be consistent with preferences, make use of judgments, and apply principles of rational behavior.

Decision Analysis is concerned largely with the problem of choice in the face of uncertainty - when consequences will depend on an unpredictable event or set of circumstances - a situation which characterizes many complex resource allocation decisions. Decision Analysis is directed at formulating and applying rational decision rules for prescriptive behaviour based on preferences for consequences but which take into consideration attitudes toward risk, judgments about uncertain events, and the cost of acquiring additional information (Raiffa, 1968:297). There are four general steps to Decision Analysis: (1) structuring the problem, (2) quantifying uncertainties, (3) quantifying preferences, and (4) evaluating alternatives (Keeney and Sicheman, 1976:173). The method can be applied to single problems or sequential problems (which involve a chain of cause-effect relationships). One way of handling the latter category of problem is to use a "decision tree", a diagram which shows the branching ramifications of the decision and outcomes involved (Coyle, 1972:25).

Some decision models are based on the assumption that the decision maker is capable of evaluating all the available alternatives and examining all the states and the outcomes. In most decisions, however, this assumption is unrealistic (Coombs *et al.* 1970). Information about future events is often too uncertain or imprecise to be used, or the number of alternatives is too large and their payoff structures are too complicated to conduct an exhaustive evaluation. In such cases, some simplification scheme is needed. One approach is to develop models for decisions under conditions of ignorance.

Decision Analysis offers several choice-criterion models which the decision maker can apply according to his attitude toward uncertainty and the perceived value of the possible outcomes. These models are concerned with the problem of making rational decisions under uncertainty; they are prescriptive in that they dictate choice given the forecast outcomes for each alternative (Green and Tull, 1978:26). Examples include the maximax, the maximin, the minimax regret, and the Bayesian.

Table D.1 provides an example of how different actions might be chosen when using these four different models. In this example, Action A is expected to have an outcome of either 10, 0 or -1,2; Action B is expected to have an outcome of 8, 4, or 0; and it is thought that Action C could only have an outcome of 3.

TABLE D.1
Choice-Criterion Models

PAYOFF MATRIX FOR MAXIMAX MODEL AND MAXIMIN MODEL

		OUTCOME		
		X	Y	Z
ACTION	A	10	0	-1,2
	B	8	4	0
	C	3	3	3

REGRET MATRIX FOR MINIMAX REGRET MODEL

		OUTCOME		
		X	Y	Z
ACTION	A	0	4	4,2
	B	2	0	3
	C	7	1	0

EXPECTED VALUE MATRIX FOR BAYESIAN MODEL

		OUTCOME		
		X	Y	Z
ACTION	A	5	3	-2
	B	5	3	1
	C	2	4	1

The *maximax* model requires the decision maker to choose the alternative that yields the maximum payoff. In the example given, the payoff matrix reveals that Action A would have the highest possible payoff of the three alternative actions (10, as compared to 8 for Action B and 3 for Action C). This model might be considered appropriate for cases in which there is relatively little uncertainty, low risk, or the decision maker is neutral as to risk.

The *maximin* model dictates choosing the alternative that maximizes the minimum payoff. In this example, Action C would be chosen, since the payoff would be at least 3 (whereas it could be 0 for Action B or -1,2 for Action A). This model might be valid if the decision maker has no meaningful information on which to base probability assignments for the various possible outcomes, or if there is high risk, or potentially large negative outcomes, or if the decision maker is very risk-averse.

The *minimax regret* model requires that the decision maker minimize the maximum regret that could be incurred. This more sophisticated version of the maximin model determines the conditional regret associated with each outcome and chooses the action which has the lowest probable level of maximum regret. In this case, it is necessary to first construct a "regret matrix". In the example given, Action B would be chosen because the maximum regret that would be incurred if the wrong choice were made would be 3 (as compared to 7 for Action C and 4,2 for Action A). Such a model might be adopted in cases of unacceptably high negative outcomes (even though they may have a low probability of occurrence), or when the decision maker is extremely conservative or risk-averse.

Finally, the *Bayesian* model uses both objective and subjective estimates of probabilities of outcomes to calculate (by multiplying the probability of each outcome by the perceived value of that outcome) the expected value of each alternative. This transforms "uncertainty" problems into "risk" problems, and the maximum expected value is then selected. In this example, assume that the expected values of each action have been tabulated as indicated in the "expected value matrix". This matrix reveals that two of the possible actions have the same expected value: both Action A and Action B have a maximum expected value of 5, whereas Action C has a maximum expected value of 4. Action B does, however, have a higher expected value than Action A in respect of one of the two remaining possible outcomes (1 as opposed to -2), and therefore Action B would be chosen. This model might be preferred by decision makers who have confidence in their ability to assess probabilities, who face problems involving partial information, and who need guidance to the important question of whether to collect more information.

Strengths of Decision Analysis

Decision Analysis is conceptually very sound and has several strengths. A major advantage is that it incorporates probability and risk assessment in an explicit way; calculations of expected value (the sum of all the possible outcomes times their respective probabilities) or expected utility (expected value adjusted to reflect attitudes toward risk) are superior to a simple calculation of value which does not take the probability of achieving the outcome or attitudes towards risk into consideration. Perhaps its greatest value is that it formalizes the decision making process and guides the decision maker through a rational examination and evaluation of the available choices: it seems desirable to have some formal procedure for dealing with uncertainty because that at least makes managerial judgment explicit and open to discussion by those involved (Coyle, 1972:25).

Even a rudimentary decision tree can help with conceptualizing the problem, identifying the critical areas of analysis and the areas of great uncertainty, and ensuring that the analysis is comprehensive and systematic and that subjective value judgments are made explicit. A decision tree can also stimulate new ideas or suggest new possibilities, and can help one decide whether to purchase new information. A not insignificant benefit of using a decision tree is that the exercise can impress upon one how little one knows about the probabilities involved, the complexities of the analysis, and even one's own value system (Coyle, 1972:27).

Limitations of Decision Analysis

There are several difficulties in applying Decision Analysis. Simple decision trees are inherently weak in dealing with trade-off situations, conflicting goals, and negative effects. They also only present a static picture and cannot handle interactions (Mitchell *et al.*, 1975:82-84). The use of more elaborate decision trees and choice-criterion models also presents some problems:

- one must select viable courses of action, and strip away non-crucial factors, so as to display the problem in a manageable form;

- one must project information costs, ultimate payoffs (utility assignments), and risks (and decide how risk averse one is), and these data are not easily obtainable and estimates are often not reliable; and

- sources of uncertainty are difficult to define and probability assignments are difficult to assign (Raiffa, 1968:34).

Complex and unique sequential problems are difficult to evaluate because of the high degree of uncertainty surrounding outcomes. And there is little point in going to the trouble and expense of performing an indifference probability assessment (Coyle, 1972:39), which involves constructing the utility curves of decision makers, if there is inadequate information on which to base probability assignments. Probabilities are difficult to estimate unless one has a large sample of outcomes, and in order to calculate expected value one needs a fairly large number of events (to demonstrate the repeatability of an event). This is very often not possible with major resource allocation decisions, which are typically unique, single-case events. In fact, for controversial resource allocation proposals there is considerable difficulty in just structuring options, and since preferences are often not well defined it is difficult to calculate utilities, so there is great potential for error (Fischhoff *et al.*, 1982).

There is a "judgmental gap" between the output of any model and the real world because of the intangibles, subjective feelings, and hunches that the model does not include. For many complex resource allocation proposals, this judgmental gap may be so wide that the analysis does not pass the threshold of relevance; the greater the subjective input to a problem, the less useful formal modeling will be (Raiffa, 1968:296).

A major difficulty with Decision Analysis is that preferences vary systematically, just as perspectives do, when the frame of reference changes. People have limited cognitive capacities and so preferences are not consistent due to different interpretations of choice situations, particularly in a complex context (Slovic and Lichtenstein, 1983). Tversky and Kahneman (1981) have pointed out that there are psychological principles which govern perception (and so influence evaluation) so that transitivity of preferences, one of the axioms on which a rational theory of decision making is based, may not be assumed. Several contextual factors can effect the shape of a utility curve (and so influence expected value calculations), and there is no objective way to identify the "correct" context for framing an evaluation problem (Hershey *et al.*, 1982). One solution is to test the robustness of preferences by framing the problem in different ways (Kahneman and Tvesky, 1984), but problems about how to define utility functions and deal with intransitive preferences weakens the practical application of Decision Analysis.

Finally, Decision Analysis has two other major difficulties: the method is dependent on the availability of the decision maker to participate in the analysis (ready access and substantial interaction are required to produce useful results), and it assumes the validity of his preferences for consequences, attitudes towards risk, and judgments about uncertain events (House, 1980). But the decision maker may be inaccessible or reluctant to reveal his true preferences, and his values, attitudes and judgments may not correspond to those who may be affected by his decision. In such cases, the output may be judged irrelevant and the analysis not useful.

Alternative Approaches to Multi-objective Decision-making

There are many other methods and techniques of decision making which have been derived from or are closely related to Decision Analysis. While provision is sometimes made for input from experts or affected parties, these methods and techniques are generally intended to utilize the judgments or assumptions of the decision maker to reveal, as objectively as possible, a set of desirable alternatives from which one can be chosen in the political decision making process (Massam and Askew, 1982). Some identify a superior alternative, or rank the set of desirable alternatives in terms of selected criteria. Others are designed to generate new and possibly better alternatives through mathematical manipulation (often computer assisted) of criteria weights. Following is a partial list of methods and techniques (arranged in alphabetical order) that were either specifically designed for or especially lend themselves to the task of guiding resource allocation decisions.

Analytic Hierarchy Process (Harker and Vargas, 1987; Khorramshahgol, 1988; Wind and Saaty, 1980; Zahedi, 1986)

Concordance Analysis (Bakus *et al.*, 1982; Massam, 1980; Massam and Askew, 1982; Van Delft and Nijkamp, 1976)

Conjoint Analysis (Antilla *et al.*, 1980; Green and Wind, 1975; Karwan and Wallace, 1980).

Design-interactive evaluation systems (Massam, 1980; McAllister, 1980; Mitchell *et al.*, 1975; Monarchi *et al.*, 1973; Peterson *et al.*, 1974; Sutherland, 1975)

Factor Analysis (Bell *et al.*, 1977; Dalkey *et al.*, 1972; Massam and Askew, 1982)

Framework Approach (Leitch, 1979)

Goals Achievement Matrix (Bakus *et al.*, 1982; McAllister, 1980)

Goal Programming (Karwan and Wallace, 1980; Neely *et al.*, 1977; Schuler *et al.*, 1977; Sinden and Worrell, 1979)

Lexicographic Ordering (Massam, 1980; Massam and Askew, 1982)

Linear Programming (Bowes and Krutilla, 1985; Jones *et al.*, 1978; Kassouf, 1970; Mitchell *et al.*, 1975; Van Delft and Nijkamp, 1976)

Multi-dimensional Scaling (Bell *et al.*, 1977; Dalkey *et al.*, 1972; Massam, 1980; Massam and Askew, 1982)

Multiple Objectives Analysis (Bell *et al.*, 1977; Cohon and Marks, 1975; Easton, 1973; Hooley, 1980; Hwang *et al.*, 1980; Keeney and Sicherman, 1976; Keeney and Wood, 1977; Millsap, 1984; Rouse and Sheridan, 1975; Schramm, 1973; Van Delft and Nijkamp, 1976; Westman, 1985)

Planning Balance Sheet (Johnston, 1977; Massam, 1980; McAllister, 1980)

Risk-benefit Analysis (Barbour, 1980; Bell *et al.*, 1977)

Scenario-building (Sutherland, 1975)

Simple Multi-attribute Rating Technique (Bakus *et al.*, 1982; Edwards, 1977; Gardiner and Edwards, 1975; Harker and Vargas, 1987)

Social Judgment Analysis (Rohrbaugh, 1979)

Structural Mapping of Indifference (Massam and Askew, 1982)

Utility Analysis (Baxa, 1981; Sinden and Worrell, 1979)

There are practical difficulties with this general class of methods which are particularly serious with regard to their application and acceptance in Third World countries. The cost of applying them is usually high in terms of money, time and effort, and they are often regarded with suspicion because of conceptual complexity (many require recondite calculations and utilize sophisticated computer programmes which may not be understood or appreciated by key parties). For example, several of these methods and techniques involve intricate and rather obscure mathematical operations geared at producing numerical "answers" which seem to make the decision for the decision maker. The mechanical nature of the process is not always satisfying to the decision maker and so there is a tendency to find fault with the procedure, particularly if the results do not accord with the decision maker's intuitive evaluation. In addition, many of these methods are characterized by inbuilt rigidities and so seem tedious or wasteful to the decision maker; others suffer from a lack of decision rules or clear guidance for applying critical procedures; and perhaps none have adequately demonstrated the ability to produce replicable results.

A major difficulty has to do with the typical decision making environment. If the resource allocation problem is especially complex it is important to have ready access to decision makers and other key parties to properly frame, analyze and evaluate the problem. But decision makers typically resort to gross simplifications when dealing with complex decision problems, and are not inclined to collect a lot of information or submit to time-consuming and mechanical processes to estimate probabilities or work out preference orderings (Janis and Mann, 1977), especially in relatively unsophisticated decision making environments. Resource allocation problems in the Third World are characterized by difficulties in gaining access and cooperation, breakdowns in communication, imperfect understanding of the dynamics of the situation, and a lack of expertise and other resources to apply the method. Under these circumstances, there is every likelihood that "errors" will be made which will produce results that are perceived to be specious or far removed from common sense judgment. This will obviously discredit the evaluation and the procedure.

Another shortcoming of some of these methods and techniques is that rather than directly evaluating the importance of outcomes, the evaluation procedure is often based on weights assigned to abstract evaluation criteria. There are two fundamental difficulties with this approach: (1) people find it difficult (and somewhat meaningless) to conceptualize the importance of criteria without reference to some specific environmental situation; and (2) the importance that people attach to a criterion will vary from situation to situation. Thus when various forecast outcomes are multiplied by criterion weights, striking anomalies can occur between the results produced by the method and the intuitive evaluation of the decision maker, in terms of both the relative importance of outcomes and (when these are summed for each alternative) the ranking of alternatives.

Finally, one of the more important criticisms of Decision Analysis and related methods is that the entire procedure is usually based on the thinking and value judgments of the "decision maker" - usually one person - who has in the course of his development been exposed to a limited set of influences, and is now operating in something of a decision making vacuum. For this reason, it can be expected that many of the concerned parties will not accept the application of any of these methods and techniques as a way to resolve disputes concerning controversial resource allocation proposals.

In spite of these general limitations, some of these methods can be helpful in specific situations when the decision maker wants guidance, understands and accepts the procedure, and is able to provide sufficient time and attention to conduct a thorough evaluation. This class of methods can prove especially useful in identifying the most promising alternatives from which a final selection can be made, and in formalizing the process of applying and trading-off evaluation criteria so that the decision maker is quite clear about the implications of the various alternatives and the rationale for his final decision.

APPENDIX E

EXPERT SYSTEMS

True "experts" are valued not only for their factual knowledge, but for their experience and insights. The mind of an expert contains many facts, but it also contains many hunches based on long familiarity with the phenomena surrounding the subject of his expertise. Experts often find it easier to give advise than to explain how they arrived at that advice - this is because their judgments are based on a mixture of analytical and intuitive reasoning (Murphy, 1988; Starfield and Bleloch, 1983).

Qualitative data play a large role in most decisions, and the expert has assimilated much qualitative data and found ways of treating it that are not so amenable to direct scrutiny - instead, the data are processed unconsciously and intuitive judgments result. But these intuitive judgments are valid often enough to make them reasonably trustworthy.

Expert Systems is an approach to structuring the judgments and insights of experts in order to develop decision rules that can be applied singly or in combination to specific problems. The idea is to capture the thought processes of an expert as he considers data, and accepts and rejects propositions, and eventually comes to a decision, and then structure these thought processes so that they can be followed by a non-expert and bring him to the same decision.

In constructing an Expert System, the thought processes of the expert are made as explicit as possible, and linked in a systematic and logical chain of reasoning. This is done by asking experts questions and exploring the reasons for their responses until a series of linked decision rules emerges which is rationally and intuitively acceptable to the experts questioned. Once the model has been built and tested, it is usually programmed as a computer package for a specific type of application. The non-expert can then consult the computer, which has now become a surrogate for the expert; this means that valuable expertise can be packaged and distributed to anyone who has access to a microcomputer.

Expert Systems can be designed through an iterative, probing procedure which forces the expert to examine and re-examine his reasons for giving a particular answer, or asking a series of questions in order to get closer to the answer. The Delphi method is one effective way in which to develop an Expert System, but individual interviews or workshops involving several experts can also be used to build the model. A common approach is to ask "If-Then?" questions; the expert is asked "If this happens, then what (will happen) (should be done)?" The expert is then questioned about the reasons for his response, until an adequate understanding is obtained to formulate a decision rule, such as "If A, then B and C", or "If A, then B or C", or "If A and B, then C", etc. These decision rules are then linked to fully address the problem under investigation, and tested to ensure they are consistent and acceptable to the relevant experts (Murphy, 1988).

Expert Systems, once developed, are powerful tools that can solve problems quickly, explicate the reasoning behind judgments and decisions, and tap intuitive knowledge and experience - *i.e.*, make the best use of qualitative data that is so often fundamental and even crucial to a decision. These systems can be updated relatively easily, and can sometimes be modified for use in another application or environment. Two or more Expert Systems can also be used under the command of another Expert System to provide what has been termed as a "knowledge-based consultation system" (Murphy, 1988:27).

Expert Systems are not always easy or inexpensive to develop, and sometimes are too narrow or limited in their application. For example, different environments have different variables, and a system developed and tested in one area may not be applicable elsewhere because a critical factor or combination of factors may exist in other areas which the system was not programmed to properly accommodate. And some problems may simply be too complex to programme at a reasonable cost, given the limited number of applications that may exist in a particular area. Ready access to computer facilities is also required.

In spite of these limitations, the Expert Systems concept has considerable potential to guide and inform decision makers on a variety of resource allocation problems, and is appealing to the decision maker because - unlike many techniques to aid decision making - it is based on principles of political rationality (see Political Rationality vs. Economic Rationality in Chapter 2): there is no reliance on quantitative methods or the use of numbers to search for optimality, but rather the object is to use sound, qualitative judgments to find a satisfactory solution to the problem. Finally, the great advantage of expert systems is that it makes expertise widely available at a reasonable cost; this is important everywhere, but particularly in a developing country with major resource allocation problems and limited expertise for dealing with these problems, as in South Africa.

APPENDIX F

PROBLEMS WITH USING PRESENT DISCOUNTED VALUE CALCULATIONS AS A GUIDE TO RESOURCE ALLOCATION

There are several reasons why calculations of present discounted value should not play the major or decisive role in the evaluation of alternative resource allocation proposals. Some of the difficulties associated with relying on present discounted value as a guide to decision making are the following.

- The benefits associated with many environmental resources cannot be priced by the market, and so are usually not included in calculations of present discounted value.
- Monetary measures of value are not necessarily accurate measures of utility.
- The present discounted value calculation is biased in favour of persons living today.

These difficulties suggest that it is not wise to attach too much importance to estimates of present discounted value as a guide to resource allocation. Following is a brief argument elaborating on this position by addressing each of the three difficulties mentioned above.

The Problem of Market Failure

The science of economics has developed an apparently rational approach to allocating scarce environmental resources among competing ends so that social well-being can be improved. Welfare economics is based on the marginal theory of value, which holds that a thing's value depends on the satisfaction the next unit can bring. Value is therefore measured by reference to the margin: an assessment of marginal utility is more meaningful to resource allocation problems than an assessment of total utility, but there are two important provisos:

- sufficient information must be available to assess accurately the true marginal utility of a good; and
- consumption of the marginal unit must not significantly alter the exchange opportunity.

If the market is functioning properly, the exchange value will reflect a good's true marginal utility and this may be considered an appropriate measure of value. Some goods, *e.g.*, water, may have a high use value and low exchange value, while others, *e.g.*, diamonds, may have a high exchange value and low use value. This paradox of value is resolved by the concept of marginal utility: it is a good's *marginal* utility that determines its value. The concept of exchange value as a measure of relative utility appears to work reasonably well for marketable goods because this value reflects the scarcity condition of a commodity, and an increase in price signals producers that there is a growing scarcity of this commodity. The market thus provides a low-cost and up-to-date information service about the relative utility of unlike goods; this system has proved to have enormous advantages over other systems for obtaining information needed to coordinate production and consumption activities (Lipsey, 1979; Samuelson, 1973). Apart from the efficiency of this service, it seems both just and right that resource allocation decisions should be based on the valuations of consumers rather than a group of "wise men" (who may not in fact be so wise).

Unfortunately, the prices of marketable goods do not always reflect the total opportunity cost involved in a transaction because valuable common property resources consumed in their production may be treated as free goods. Goods which cannot be owned and exchanged in the market are likely to be valued incorrectly, or not at all, yet these common property resources may make significant contributions to social well-being; their use value may be high but poorly perceived, particularly at the margin, and exchange value may always remain indeterminable.

Two important conditions to the proper functioning of a market are the specification of property rights and the availability of perfect information. However, in the real world many property rights cannot be specified, and consumers have limited experience, knowledge, and foresight to accurately evaluate the utility of certain goods (particularly with respect to goods provided by the natural environment). Since consumers have limited information, their expressed wants do not constitute a reliable guide to improving welfare. As a result, allocative processes in the market may be expected to result in sub-optimal choices. Common property resources are being exchanged for consumer commodities, but the exchange process is very complex and not clear to the average consumer (Wollman, 1967). For example, the average person is not likely to see the connection between his consumption of some good and the ecological or amenity costs that may result. If it is true that the consumer is not competent to evaluate utility at the margin for many goods, then it may be necessary to rely on the value judgments of specialists and to devise institutional mechanisms for ensuring that unpriced goods are given appropriate exchange values so that consumers will be led to make more rational trade-offs with priced goods.

In addition to the above difficulties, it is questionable whether the human mind can adequately comprehend the social value of very large amounts of money; the present discounted value is normally a large figure which cannot readily be interpreted in terms of more tangible goods and services, or easily compared with the value of unpriced impacts. The decision making problem is not simplified or much facilitated if one must try to compare the value of millions (or even hundreds of thousands) of rands with the value of a long list of nonmonetizable impacts to natural amenities and ecological processes.

There is another reason for believing that conventional economic theory and practice may now be less reliable as a rational guide to improving social well-being. In a rapidly changing world environmental impacts are increasing at a rate and on a scale that is totally unprecedented. Some of man's adverse impacts on natural ecosystems have already gone far beyond the marginal, and given our great ecological ignorance, it may no longer be rational to make allocation decisions by reference to the margin. By the time we feel the full effects of our actions it may be too late to escape costs which suddenly escalate to the point of becoming an unbearable burden.

Most economists agree that natural resource exploitation is subject to a number of different types of market failure (Common, 1988; Rees, 1985), and even though there may as yet be no solid evidence that continued economic growth will result in greater resource scarcity, Barnett and Morse (1963:266) have suggested that there is a need to develop new institutions or mechanisms to supplement market allocation, and these should be based on objective determinations of what is good for man, or for society as a cooperative enterprise. The problem is that . . .

> . . . of all social processes, the most mysterious and least subject to guidance are those by which value standards are formed and changed. But the formation and modification of a social value consensus is . . . a crucial object of concern. We think it would be desirable to act on the assumption that it is, in fact, possible to apply a more objective methodology to our value problems than we have been accustomed to believe. . . .

The Problem of Individual vs. Collective Valuation

Even if consumers had "perfect information", and other conditions for the operation of a "perfect market" were met, market and shadow prices still could not be used to allocate scarce resources in a socially efficient manner. This is because "rarity value" - the value attached to acquiring a good because it is rare - often constitutes a significant proportion of an individual's valuation of a good's utility, and this component of a good's market-based value does not contribute to social well-being. Any measure of value which varies negatively with improvements in social efficiency and just distribution cannot be used to gauge whether an action constitutes a social welfare gain.

Since individuals attach value to gaining some relative advantage over other individuals, and since advantage implies disadvantage, individual valuations cannot be directly aggregated to obtain social valuations (Daly, 1987:331). A valid criterion of social value must be based on the intrinsic or absolute utility any good has for individuals and for society in general, and cannot take cognizance of individual perceptions of utility which depend on some degree of deprivation on the part of other members of society. It is therefore necessary to consider what proportion of a good's price (which is a measure of its "scarcity value") is attributable to its intrinsic value and what proportion to its rarity value. Its intrinsic value is based on utility directly obtained, irrespective of other people's knowledge or possession of the good, and its rarity value is based on utility indirectly obtained, depending on other people's knowledge or possession of the good. The rarity value should then be factored out (*i.e.*, the market or shadow price adjusted downward) to remove the social distortions of individual valuation.

For example, the market price of a glass of water reflects its scarcity value (the opportunity cost of obtaining it), which is determined solely by its intrinsic value (the direct utility conferred) weighed against the value of goods which must be foregone to obtain it. (Rarity value is not a consideration because the fact that *other* people are thirsty would presumably not increase the marginal utility of a glass of water to the person purchasing it.) But the market price (or scarcity value) of a diamond necklace has two components of value to be weighed against its opportunity cost: (1) its intrinsic value (*i.e.*, the direct utility conferred by its beauty and durability), and its rarity value (*i.e.*, the indirect value from possessing a good that others covet - in other words, the fact that other people desire but do not possess the good increases the marginal utility of a diamond necklace to the person purchasing it). Individual demand curves for potable water can be aggregated to obtain a market demand curve which fairly approximates the true social utility of potable water, but a market demand curve for diamond necklaces does not reflect the true social utility of diamonds because the individual demand curves are based largely on the degree to which other people are deprived of diamonds.

The Problem of Future Generations

Cost-benefit Analysis is concerned with maximizing the net benefits to society, but the socially relevant time horizon needs to be defined. Planning and decision making is obviously "forward-looking", but the question is what are the time periods with which present planners and decision makers are concerned, and how should costs and benefits of one time period be compared with those of another? The standard approach is to define a socially relevant time horizon of up to 50 or perhaps 100 years, and to apply a positive rate of discount to the time stream of costs and benefits which is based on the current opportunity cost of capital or the present social time preference rate (Dohan, 1977; Sharp, 1981). However, this approach effectively ignores the effects of resource allocation decisions on future generations because even a small positive rate of discount will reduce the value of a large but remote cost or benefit to a negligible amount (Pearce, 1983).

But there is no logical reason to restrict the definition of society to present individuals, or to favour one generation over another due to its position in time. If one accepts that society should be defined in terms of both present and future generations, and that the well-being of all generations is of equal importance (see Defining Evaluation Criteria in Chapter 4), then measures of value based on conventional discounting practices are inadequate as a guide for allocating environmental resources (Hollick, 1981a; Page, 1977; Price, 1973).

Yet it is still common practice to base resource allocation decisions largely on projections of present discounted value (or other performance criteria of interest to present generations), and to essentially ignore the implications of these decisions for future generations (Daly, 1987;

Goodin, 1982). The conventional argument is that one should be primarily concerned with seeking efficiency improvements (maximizing present discounted value) to increase the general level of benefits available for consumption. The next priority is to take redistributive measures, if and when required, to redress any inequities from production activities. And finally, since future generations should also benefit from economic growth and technological advance, it is assumed that it should not be necessary for present generations to make special sacrifices to provide for their well-being (Baumol and Oates, 1975, 1979; Beckerman, 1972, 1974; Seneca and Taussig, 1979).

But there is a countervailing argument which is becoming increasingly cogent because there is growing evidence that mankind is entering a new era in which production activities are having irreversible regional and global impacts which pose considerable risk, and which could ultimately lead to unacceptable levels of well-being for future generations (Boulding, 1971; Mishan, 1969, 1977; Page, 1977). Many of nature's "public service functions" (*e.g.*, life-support systems and natural amenities) are being impaired or destroyed by economic activity. Examples are acid rain, destruction of the ozone layer, the widespread loss of species and major ecosystems, and changes in weather patterns and rises in sea level due to the "greenhouse effect" (Clark, 1989). This new evidence indicates that while the great (and almost exclusive) emphasis on present discounted value calculations as a guide to resource allocation may have been reasonable in the past (because it always appeared there would be sufficient resources available to future generations), present patterns of development and resource allocation may leave future generations without the means to support a secure and satisfying existence. Conventional Cost-benefit Analysis does not take cognizance of this new insight into man's environmental circumstances.

It now appears that for certain critical environmental services the consumption of marginal units is beginning to affect the exchange opportunities that are available. This could lead to a special case of scarcity, associated with the concept of consumer surplus (and analogous to the ecologist's concept of ecosystem thresholds that, if breached, can lead to systems breakdowns): a condition when further losses (or reductions in the exchange opportunity) would constitute such great and irreversible costs that they would be regarded as totally unacceptable (Spies, pers.comm.).

In this new situation, what is called the "economic problem" - the problem of scarcity - becomes more of a "moral problem" (Daly, 1987). When limits are being approached, the most significant thing about the concept of scarcity is not that an individual must choose to have less of one thing in order to have more of another, but that he must choose how much he is to have relative to what others may have, both now and in the future. It is not then just a question of seeking efficiency improvements; it is perhaps more important to consider what degree of risk and deprivation one is imposing on disadvantaged groups and future generations (Rees, 1985).

Under these circumstances, if the goal is to achieve the highest possible level of social well-being over a very long time horizon (spanning multiple generations), marginal analysis may be less relevant to resource allocation proposals than an analysis of distributional effects and potential sustainability. The new environmental and moral dimensions of resource economics suggests that the conventional ordering of the three criteria for achieving this goal should now be reversed: one should first require that the sustainability criterion not be violated; the next consideration should be whether the equity criterion is adequately satisfied; and only then should the efficiency criterion be applied.

In developing an approach to this new situation, one might be guided by the following considerations. There are two general classes of goods which contribute to man's well-being:

- goods which *can* be produced or re-created by man to meet demand (*e.g.*, motor cars, operas, nuclear power plants); and
- goods which, for technical or practical reasons, either *cannot* be produced or cannot be re-created by man to meet demand (*e.g.*, soil, natural landscapes, historical buildings).

The first class of goods yields benefits for a finite time, and their production involves certain costs (labour and capital costs) which are non-recurring and no longer felt after a short period of time. Discounting treatment seems acceptable for these benefits and costs because future generations are essentially unaffected. The second class of goods, however, is capable of yielding benefits indefinitely at low maintenance costs (in terms of labour and capital), and some may be regarded as having no suitable substitutes and as being essential to survival or maintaining a high quality of life. It therefore seems inappropriate to discount the future value of benefits flowing from such goods in a simplistic way.

Planning optimal consumption patterns for nonrenewable resources would only involve consideration of whether and when substitutes can be developed. However, losses of many renewable resources which would be incurred in the production of manmade goods could constitute significant (and permanent) costs which would seriously affect the well-being of future generations long after these goods are consumed and the benefits are exhausted. These costs are foregone opportunities to appropriate benefits flowing from potentially renewable or sustainable goods which are destroyed or impaired in the production process. It would seem more appropriate to discount the future value of these costs at a zero or negative rate, or to give them some special weighting in the cost-benefit calculus.

For this special class of goods, the treatment of different time streams of costs and benefits could simply be based on judgments as to the good's contribution to some basic human need, the prospects of finding a satisfactory substitute, and the implications of losing it forever. The future value of natural and cultural goods which can provide benefits on a sustainable basis can be expected to increase significantly relative to that of benefits from other goods (Krutilla *et al.*, 1972). One can anticipate an increasing demand for these goods if one accepts that a growing population facing the exhaustion of nonrenewable resources and the prospect of even greater impacts on ecological processes and natural amenities will become more dependent on remaining life-support systems, will face greater competition for amenities in fixed supply, and will need to make greater use of renewable resources to survive.

Most economists discount these worries and take refuge in the demonstrated responsiveness of market mechanisms and modern technology. The argument is that as environmental problems become acute and shortages of environmental resources develop, other resources will be reallocated to alleviate the problems, and new resources or substitutes will be discovered because of market incentives. And of course, it is possible that future generations will not have serious resource shortages or ecological problems because they will have developed technological solutions for dealing with these problems, and it is also possible that future generations will not desire natural amenities (*e.g.*, special features like wild and scenic rivers, or extensive natural settings like wilderness areas, which accommodate certain outdoor recreational activities) because they will have developed new tastes and preferences. The ingenuity and adaptability of human beings has confounded Cassandras before, and it is possible that mankind will prove sufficiently resilient and resourceful to always prevail.

However, the experiences and insights of ecologists suggest another view: certain biological systems and ecological processes should be regarded as essential resources which have no acceptable substitutes, and man's ability to manage these resources is limited by time and information constraints. Economic feedback mechanisms may be frustrated by market and political inertia, and technological lags may prove intolerable. There must be some ultimate limits in a finite world, and the odds of reaching at least one critical limit when the scale and rate of transformation is increasing exponentially are frighteningly high.

Even if man develops satisfactory substitutes for nature's public service functions and manages to maintain life-support processes, the loss of natural amenities could significantly reduce the quality of life. While man has proved to be an adaptable creature, there is ample evidence that his sense of well-being is dependent on his environmental circumstances, and that natural amenities have contributed greatly to his quality of life. Some resource economists believe that economic growth and prosperity will lead to greater efforts to preserve natural amenities (Krutilla *et al.*, 1972). This is because concern for natural amenities appears to be correlated with higher incomes: as more people attain higher incomes, we might expect a greater demand for these amenities and a corresponding willingness to pay for them. But there is another possibility: suppose increasing population and changing lifestyles result in congestion effects and new tastes and preferences, so that people become alienated from natural influences and the utility of natural amenities becomes obscured? This in fact seems to be happening with urban populations around the world, so that the quality of life may be insidiously declining as man becomes gradually "denatured" (Allsop, 1971:xv; Milbrath, 1982:8).

As already mentioned, one possible solution to the problem of how to take adequate account of today's resource allocation decisions on the well-being of future generations is to extend efficiency analysis over intergenerational time periods by applying some system of weights (rather than a fixed discount rate) for measuring the relative importance of benefits received at different time periods, or some form of differential discounting applied to different categories of costs and benefits (Goodin, 1982; Kneese and Schulze, 1985; Sharp, 1981). A selective approach would appear preferable to the present procedure of applying a more or less arbitrary rate of discount which is unrelated to precise definitions of social well-being and which is based on the questionable premise that satisfactory solutions will always be found for tomorrow's problems. Special discounting procedures could be developed for evaluating the significance of costs and benefits to present and future generations in light of the following time-related propositions:

- Goods which are potentially renewable or can provide a sustainable flow of benefits are of greater value to society than goods which are not renewable or sustainable.

- Goods which can be produced without imposing significant long-term or irreversible costs on society are of greater value to society than goods which do impose such costs.

- Goods which have no satisfactory substitutes, and which are unlikely to ever have substitutes, are of greater value to society than goods for which substitutes exist or are likely to be developed through technological progress.

- Goods which satisfy some essential need or enhance the quality of life are of greater value to society than goods which are obviously non-essential or do not enhance the quality of life.

The problem with this solution is that it would be difficult to devise a practical system of weights or differential discounting that would gain wide acceptance. Another possible solution to the problem is to accept the present discounted value measurement of Cost-benefit Analysis as one factor (and an imperfect one) in judging the efficiency of a proposal, but from the point of view of present generations only. Then one would apply a separate criterion - the sustainability criterion - to evaluate the implications of a resource allocation proposal for future generations. The idea is that, in addition to considering how costs and benefits would be distributed over present populations, one would also consider how they would be distributed over multiple generations, and then make explicit trade-offs with the efficiency criterion. This is the solution that is recommended in this dissertation.

APPENDIX G

THE RATIONALE FOR DEVELOPING A NATIONAL CONSERVATION POLICY TO CONSTRAIN RESOURCE ALLOCATION OPTIONS

To many people, it may not seem desirable - or even morally defensible - to safeguard elements of the natural environment, and refrain from exploiting every available resource, while there are human beings who are suffering greatly from deprivation today. It is obviously difficult to think about providing for the needs of future generations when one is faced with such desperately low levels of welfare amongst people living today, particularly in countries like South Africa and other parts of Africa. But if one plans only for today, and fails to make a firm commitment to posterity by conserving some of the earth's bounty, even greater suffering could befall mankind.

Hardin (1977a) feels that mankind is entering a new and desperate age which will demand new attitudes and ways of thinking, and that we should now interpret ethics on a supra-individual level. His analysis suggests that decision makers should be more concerned about the long-term needs of mankind than about the immediate needs of specific individuals today, which implies that first priority should be given to maintaining the carrying capacity of the earth (Hardin, 1977b). Daly (1987) has also argued that new directions and priorities are needed to guide economic development and ensure that social progress is sustainable.

Whether one agrees with the arguments put forward by Hardin and Daly, the concept of maintaining a reasonable level of environmental services, given mankind's new environmental circumstances and growing environmental predicament, seems a prudent policy to adopt. Such a policy would then establish the boundaries or context within which more specific problems of choice can be addressed.

While some resource economists have maintained that there are no ultimate limits on resource use, and that the "exhaustion of resources argument" is fallacious (Common, 1988; Seneca and Taussig, 1979), intuition and reason both suggest that if resource allocation decisions are made in isolation from one another, a series of apparently optimal decisions can eventually lead to a sub-optimal result. Therefore it is necessary to consider the context within which the evaluation of specific proposals occurs, and decide whether to establish a national conservation policy that would constrain choice at the national, regional and local levels. An argument for adopting such a policy is presented in this appendix.

The Need to Constrain Choice

Every development action has consequences on two general levels: the first is for that area and time period explicitly considered by planners and analysts, and the second is for a wider area and longer time period which lies outside the normal planning time horizon and boundaries of analysis. The first level is subject to greater control and is more amenable to analysis than is the second; although there is no sharp distinction between the two in terms of space or time, as one goes farther from the geographical center of the action or becomes more removed in time from the moment when the action was taken, the consequences of the action tend to become more and more muddled with the consequences of other actions taken elsewhere and at other times. The important result is that any resource allocation strategy and research methodology concerned solely with the planning and assessment of specific actions, even if applied universally and performed competently, cannot in itself ensure the attainment of a socially optimum position because of possible cumulative and synergistic effects with other actions. The decision space at the more narrowly circumscribed level should, therefore, be constrained by policy decisions at the more general level.

Krutilla says decision makers must take a broad view of resource use as a system which needs all its parts, and not make trade-offs in isolation (Krutilla, 1967). Individual actions have numerous and subtle "ripple effects" or complex ramifications which will not be perceived in any given assessment, and these effects will preclude, from a national or international point of view, attainment of a socially optimum allocation of resources (Mack, 1977:112).

Apart from the very real problem that it is impossible to effectively apply any environmental evaluation methodology to every resource allocation decision, each plan and assessment is necessarily limited in scope, so that ultimate effects (in combination with other decisions) will remain undetected by any given application of the methodology. The inevitable result of taking many decisions in isolation, if choice is unconstrained, is that society will move from one sub-optimal position to another, even though each decision is based on a rational evaluation.

Planning and assessment of specific actions should, therefore, be considered within a broader context, in which limits have been established for resource usage in order to ensure that parochial and short-term social objectives do not always dominate. A holistic, long-term, national and even global perspective is needed to direct and coordinate development actions to avoid the piecemeal abuse and destruction of environmental resources. There is thus a need to establish a policy framework within which the environmental evaluation methodology is to operate, and which prescribes other policy instruments as well.

Without such a policy framework, development actions will continue to be guided by discrete and unrelated assessments that assume the status quo will be maintained elsewhere. This makes possible the destruction of resources on the assumption that substitutes will continue to be available, when in fact the substitutes themselves are being destroyed on the same argument (Price, 1977:95).

To take a specific example: should policy allow recreational housing developments in the coastal zone to displace or impair the functioning of what has been termed "vital areas" of coastal ecosystems (Clark, 1974:59)? Although such developments might meet all the evaluation criteria from a local or regional perspective, they may still not be in the best overall interests of society. These developments benefit few individuals directly and - when considered in conjunction with similar developments in other locations - adversely affect many indirectly (e.g., through decreased fishery production, lost recreational opportunities, and reduced open space in the coastal zone), and such resources are already, from a national and long-term perspective, extremely scarce in South Africa. The real policy questions are:

- Should a few people be allowed to monopolize a scarce resource, such as an estuary or coastal wetland system, and

- Should there not be some minimum level of these resources preserved in perpetuity regardless of the implications for the efficiency objective?

Isolated developments which contribute to the degradation of estuaries or eradicate wetlands do not seem very significant, but such developments are becoming more numerous and should at some point be curtailed, or else valuable and irreplaceable resources could be lost completely to the nation.

Policy planners need to look at long-term national trends and establish the long-term needs of the larger society. Evaluations of specific, localized projects tend to be done *in vacuo*, and this can lead to insidious results: externalities that in isolation appear insignificant may have cumulative effects which will eventually become significant and perhaps unacceptable. Ecological functions can become impaired and natural amenities can become degraded on a large scale if a policy is not adopted to control the utilisation of common property resources. If a *laissez-faire* attitude is taken, and there is unrestricted competition for a common property resource of importance to the nation, the use generating the largest negative externality is likely to prevail.

For example, if two groups are using a coastal wetland, one to observe the birdlife and the other to ride trail bikes, the birdwatchers will have no impact on the trail bike riders, but the latter could have a significant impact on the birdwatchers, who may then be forced to go elsewhere. But if the same phenomenon is occurring everywhere, the time may come when there are no suitable areas for observing birdlife available to these people and then they (or their children) may give up birdwatching and perhaps take up riding trail bikes. And so externality effects may favour recruitment to the externality-imposing activity. This pervasive problem is likely to become more serious as population increases and crowding leads to more conflicts in resource usage.

It is therefore very important to create institutional mechanisms to counteract these displacement effects, or the availability of natural amenities will be so reduced that their potential to enhance well-being will be severely diminished; similarly, important ecological processes can be irreversibly damaged. The multiple-use concept (Bowes and Krutilla, 1985) and recreational opportunity spectrum concept (Clark and Stankey, 1979) are both concerned with meeting a broad range of resource demands without sacrificing the resource base necessary to meeting any one of these demands. This can be done up to a point, but ultimately there must be limits for particular activities; the obvious solution is to prescribe single-use areas and protected areas for those activities and environmental services that are considered especially vulnerable. While some recreational housing in the coastal zone should obviously be allowed, and some provision for trail bike riding in appropriate areas should be made, these resource uses should not be allowed to become too ubiquitous. Planners and decision makers have a special responsibility to provide an environment which offers diverse opportunities and keeps options open for the future (Mishan, 1969).

Many scientists and economists envision a future in which the only essential raw materials will be energy and the most basic chemical molecules, which will be readily obtainable from sea water and rock. Some resource economists have claimed that there is no danger that welfare improvements will be checked by the exhaustion of natural resources because of the ability of the market system to adapt to the threat of shortages, and because of the prospect of continued technological advance (Baumol and Oates, 1975, 1979; Seneca and Taussig, 1979). But while this claim may be valid in the case of marketable commodities, it is highly dubious when applied to environmental services such as ecological processes (at least those which contribute to essential life-support systems - *e.g.*, the creation and maintenance of topsoil, climatic processes affecting temperature and rainfall patterns) and certain natural amenities (those which are highly valued, have no substitutes, and cannot be created by man - *e.g.*, Table Mountain, the Fish River Canyon). Natural organisms, ecological processes, ecosystems, and geological features are valuable natural resources which are not amenable to market solutions because they are common property resources, and once lost, there are no technological solutions to the problem of replacing them. In addition, these resources often enhance the quality of life, and some significantly contribute to the prospects of survival, yet many - which are vulnerable to destruction - have no satisfactory substitutes.

Dohan (1977) has pointed out that once certain "public service functions" of nature are lost, it may not be possible to restore them, for both technical and economic reasons. The loss of these public service benefits adversely affects society in two ways: it reduces environmental quality, and it forces society to use economic resources to replace in part the public service functions of the natural environment, or to keep environmental quality from declining further. Society may then find itself in a position where the added cost of restoring environmental quality or providing services once obtained from natural ecosystems is unacceptably high, so that the socially optimal position is to remain at a less satisfying level of environmental quality and social well-being. This suggests that society should exercise great caution, and be prepared to accept high opportunity costs, to minimize the risks of slipping into a regrettable but effectively irreversible situation. Miller and Ladd (1984) has proposed a two-stage decision model for problems with irreversible effects which permits learning from the first stage.

Krutilla *et al.* (1972) have suggested that decisions which have irreversible effects on the supply of renewable resources entail a special responsibility and differ in character from decisions which can be undone if the consequences are deemed undesirable on hindsight, and therefore in a world of great uncertainty there is great value in the retention of an option which would otherwise be foreclosed. In order to keep options open, special consideration and treatment should be given that portion of the existing stock of natural resources which is capable of generating benefits in perpetuity. Biological resources, natural landscapes, and ecological processes are examples of irreproducible assets which may have no satisfactory substitutes. Since these goods and services of nature can provide benefits in perpetuity, stocks should be maintained above some minimum level to ensure their continued provision for society.

There is great value in maintaining options, especially when uncertainty and irreversibilities are encountered and could be significant, or one can expect lagged responses to lagged consequences, such as depletion of the ozone layer (Fisher and Krutilla, 1985). A strong argument can be made that population, economic and technological growth are creating a highly volatile and dangerous situation which threatens the future, and which demands a new, more risk-averse strategy of resource management. The environmental problems which face modern society are potentially very serious. Never before have problems of congestion and resource depletion and degradation been so wide-spread; impacts are now occurring at a rate and on a scale that is totally unprecedented and which threatens the quality of life, and even the prospects of survival, for much of the world's population (Global 2000 Report, 1980). Many environmental problems are characterised by great uncertainties as to their causes, effects, and potential solutions. Given this situation, a strategy which favours risk-reduction would seem desirable - such as adopting the minimax regret criterion model (see Decision Analysis in Appendix D) - and this means adopting a policy which puts greater emphasis on the concept of sustainable development (Allen, 1980; Clark, 1989; International Union for the Conservation of Nature, 1980; World Commission on Environment and Development, 1987).

According to Page (1977:11), "intertemporal equity" is an important problem because there is no way to add up the costs and risks along with the benefits and no way to guarantee that the future is going to be better off than the present. There are at least three difficulties:

- uncertainties in estimating future costs and risks;
- deciding what is a fair distribution of costs and risks between generations; and
- persuading the present generation to accept its share of costs and risks.

But one can make a strong argument, based on utility theory, that risk aversion is rational in modern industrial society because of the diminishing marginal utility of goods (Weston and Brigham, 1978:359)); we should be more concerned with losing a unit than gaining a unit. This is particularly true in the case of irreplaceable environmental services, which are becoming increasingly scarce relative to consumer commodities, and for which the "consumer surplus" should now be considered. Dohan (1977:146,164) has said that the concept of consumer surplus provides the theoretical basis and rationale for calculating the value of common property resources, and suggests that large changes in the supply of environmental services require that the loss in consumer surplus be estimated. When the supply of a resource which has great intrinsic value and no close substitutes is rapidly declining, the significance of such considerations as irreversibility, "*option demand*", "*nonparticipant demand*", "*bequest motivation*", the welfare of future generations, uncertainty and risk are especially great.

Risk-benefit analysis is primarily concerned with health and safety considerations. In decision theory, a risk is defined as the probability of an occurrence multiplied by the magnitude of the consequences (Barbour, 1980:175). There may be high risk in ecosystem destruction even though there appears to be a low probability of adverse effects occurring, because the consequences of error or unexpected sequences of events in large-scale systems can be enormous. What Bell calls "cost-benefit-risk analysis" incorporates uncertainties: the decision criterion often used is to maximize the benefit-cost ratio with the restriction that the risk should not exceed an acceptable level. (Bell *et al.*, 1977:9).

If this line of reasoning is accepted and a policy emphasizing risk avoidance is promulgated, then the social welfare function should be modified to explicitly take into account the implications of resource allocation decisions for future generations. Herfindahl and Kneese (1974:389) have suggested that economic analysis would be more relevant if such considerations were incorporated into the definition of the welfare function, and have even suggested the adoption of a decision rule that would constrain resource allocation options:

> Our actions should not be such as to foreclose the attainment of a position with respect to nonexhausting resources by future populations that is attainable by us.

Such a strategy - which accords with the idea advanced by Page (1977) that preserving opportunities for future generations would serve intergenerational justice - would necessarily entail some reduction of material and energy flows so as to maintain environmental services at a higher level, which would to some degree adversely affect the efficiency of production, but it may be that this strategy would not seriously exacerbate the present maldistribution of income and wealth. In fact, the effect may not only serve the sustainability objective by maintaining environmental services, but may also serve the equity objective by narrowing the income gap between different groups.

Some reduction in the level of output would not necessarily adversely affect individual or net social well-being. Herfindahl and Kneese (1974:389) have suggested that reduced material and energy flows could result in a radical change in the composition and/or level of consumption, but they note the enormous flexibility with which consumers can reform their budgets so as to provide satisfying lives in spite of such changes. This suggests that the link between material goods and welfare has been overemphasized and that it may be worthwhile to revise the social welfare function:

> In elaborating these possibilities, it probably would be useful to experiment with more specific forms of the social welfare function, partly to make ethical implications more explicit. One possible modification . . . would be to abandon the monotonic relation between welfare and goods, perhaps thinking of the same level of welfare as attainable with widely different quantities of goods and services, provided certain specific minimum requirements are met (Herfindahl and Kneese, 1974:397).

This accords with Juster's (1977:24) suggestion that it may be more appropriate, in our new environmental circumstances, to seek to "minimize illfare" rather than "maximize welfare" because for every individual there may be critical values - satisfactions above some minimum - without which overall welfare is perceived to be at low levels regardless of satisfactions with other aspects of life. There is no point in maximizing the consumption of several variables if it means not achieving some minimum level of one variable which in turn results in a low level of well-being.

In support of this line of reasoning, one can cite the theory of psychological well-being advanced by Maslow (1969, 1970). Maslow has postulated that there is a hierarchical structure to man's needs and that higher needs only emerge when lower needs are gratified. If one accepts this theory, and determines that resource use is to be directed at <u>satisfying</u> man's true, biologically-determined <u>needs</u>, rather than <u>overgratifying</u> these needs or simply satisfying <u>wants</u> (which Maslow describes as false, culturally-induced needs), then resource demand can be reduced and stocks maintained even at relatively high population levels.

Boulding (1971) has also suggested that the success of an economy should not be measured by its throughput - its production and consumption - but by the extent and quality of its total capital stock. As the supply, quality, and complexity of a society's total capital stock declines, the prospects for achieving income flows necessary for improving or maintaining social well-being are diminished. The ideal Boulding proposes is to improve human welfare in ways that minimize throughput and so maintain stocks. Boulding calls for a transition from the "cowboy economy" - one of reckless extravagance - to the spaceman economy - in which restraint and balance prevail, and the goal is not to maximize consumption but to achieve an acceptable state of social well-being with a sustainable flow of resources. Given the rapid growth of world population and the growing disparity between the rich and the poor, and the increasing risk of economic, social and political disruptions associated with environmental degradation and resource shortages (and which could lead to economic and social collapse, or "resource wars"), this approach has much to commend it (Stauth, 1980).

The above arguments make a strong case for adopting a new policy which is less concerned with the production and consumption of material goods that are destructive of environmental services, and more concerned with finding ways to provide acceptable levels of well-being with low levels of resource inputs. Such a policy would also be preeminently concerned with maintaining diversity and keeping options open.

This accords with the central idea of economic development, which might be defined as organic change within an economy which results in increased opportunities for satisfaction or freedom of choice (Stauth, 1983a:83). Krutilla and Fisher (1975) maintain that a central postulate of welfare economics is that an expansion of choice represents a welfare gain; reduction of options a welfare loss. Krutilla (1967) says that if resource allocation decisions are made as alternatives come up, one at a time, it seems reasonable to expect that less common tastes will be extinguished over time and development will lead to a dull uniformity. Mishan (1969) also states that improving freedom of choice is fundamental to improving welfare, and he proposes the promulgation of laws and regulations to establish a wide variety of environments to maintain those natural amenities which could not survive marginal comparisons in a situation which is common to all; this would provide people with truly meaningful choices, rather than the trivial choices associated with a mass consumption society. Mishan (1981) also suggests that actions with potential intergenerational consequences should only be taken if they can make one generation better off without making any other generation worse off.

All of this suggests that certain elements of the natural environment should be given a special status when devising a resource accounting scheme or a resource allocation strategy. These special elements would be resources which

- are thought to have significant survival or amenity value
- are renewable (or have the potential to confer benefits in perpetuity)
- are regarded as being inherently irreproducible (except over geological time periods)
- are considered unlikely to ever have suitable substitutes.

For these resources, a national conservation policy is needed which is directed at ensuring a sustained yield of benefits.

Policy Options

Policies are broad, long-range formulation-based constraints on action (Sutherland, 1975:463). They are based on certain *a priori* premises, such as, for example, the view that one individual's welfare is as important as that of any other, and the view that the resource base is owned jointly across generations (Page, 1977:xv). Accepting these premises, a reasonable guide to developing policy would be to adopt the Rawlsian position that planning should be done as if behind a "veil of ignorance" (Page, 1977:203), on the assumption that if the planner or decision maker did not know what his position in society would be, he would make a special effort to allocate resources equitably amongst all groups in society, no matter how placed in space or time. The object of such an approach would be to constrain the decision space available to members and institutions of present-day society in order to better serve the larger and longer-term interests of society.

Evaluations of resource allocation options at the project level (and sometimes at the programme level) tend to overemphasize the efficiency criterion, because decision makers commonly place great faith in "trickle-down" effects and the power of economic growth and technological advance to eventually resolve any adverse intra- or intergenerational distributional problems that may arise. There seems to be no way to give more force to considerations of equity and sustainability in the conduct of evaluations which are, by their nature, narrowly circumscribed, because of the assumption that sufficient resources will always be available to eventually redress imbalances, rectify injustices, and replace losses that may result from implementing a more efficient development action. For this reason, policy makers need to take special cognizance of these neglected considerations and formulate an environmental management policy, as well as the legal provisions and administrative procedures for giving effect to the policy, to ensure that some minimum level of specific environmental services will always be maintained.

At the heart of a policy based on this paradigm would be an overriding concern with social justice and conservation, since to ignore these two issues in today's world of growing social tensions and rapidly increasing demand for resources of all kinds is to accept a significant risk that social progress will not be sustainable (Stauth, 1980). Overarching such short-term considerations as political and economic expediency are considerations of what, in the long-term, will be socially and biologically acceptable. Major challenges are to control the exploitation of common property resources, adopt an effective population policy, develop instruments for efficiently collecting and distributing transfer payments, identify levels of maximum sustained yield for renewable resources, and calculate optimum depletion rates over time for nonrenewable resources. These considerations are of particular importance in the Third World, where the carrying capacity of the environment is being undermined at an alarming rate (Biswas and Geping, 1987; Pearce, 1988; Rees, 1985; Global 2000 Report, 1980).

The success of a society should not be measured by its gross national product, but by the level and distribution of well-being, and the nature, quality, and extent of its capital stock (Boulding, 1971). Distribution and capital-stock concepts must be regarded as fundamentally more important than production and consumption concepts, and efficiency gains should not be allowed at the expense of gross distributional injustice and long-term jeopardy. Since it is the efficiency objective which tends to predominate in individual assessments and in the short-term, policy analysis should be directed at constraining the efficiency function so that efficiency improvements are subject to satisfying specified criteria relating to the equity and sustainability objectives (see Defining Evaluation Criteria in Chapter 4). The intent of such a policy would be to ensure that

- the distributional effects of resource allocation will steadily improve, and

- the prospects that future generations will be left with the means to enjoy a secure and satisfying existence (at least comparable to that enjoyed by present generations) will not be diminished.

This could be accomplished if those who benefit from an action were <u>required</u> to take actions which would in effect compensate those who suffered costs, and maintain environmental services for future generations. This could take the form, for example, of legislation mandating payment of a severance or use tax, which could be used to effect transfer payments, and requiring the accomplishment of a "shadow project" to maintain or restore previously existing levels of environmental services (Page, 1977; Pearce, 1988).

Devising a Planning Policy Based on a Resource Accounting System

Planning is the process of preparing a set of decisions for action in the future, directed at achieving goals and objectives by optimum means (Martino, 1972:332). From a national planning perspective, pursuit of the social goal and objectives (see Defining Evaluation Criteria in Chapter 4) is vastly complicated. The maximization of social well-being requires the generation of various kinds of information, not summable into a single number (or even subject to methods of analysis strictly based on quantification), as a basis for political decisions. The complexity of the problem and the dearth of reliable information for analyzing that problem precludes rigorous analysis and precise solutions, but it is possible to alter the institutional environment in a way that is designed to ensure that, even if optimization is not possible, the prospects are greatly improved that decisions will at least take society in the right direction (see Political Rationality vs. Economic Rationality in Chapter 3). Changes in the institutional framework within which decisions are taken can act as a new "invisible hand" to improve social well-being (Kelso, 1977:819).

One policy objective would be to establish minimum levels for the provision of specific environmental services, and another would be to promote uses which generate the lowest negative externalities and maintain the availability of a resource for the benefit of all. These objectives can be furthered through the application of a variety of policy instruments. For example, the domain of rights is part of the checks and balances on the market designed to preserve values and maintain a balanced set of objectives (Okun, 1975:13). One solution is to pass legislation that assigns rights in environmental services to those whose use of these services does not inflict spillover (external) effects on others. Mishan has shown that as long as the law tacitly approves environmental spillovers, a much lower level of environmental quality will prevail, and be considered optimal (in efficiency assessments), then would be the case if legal rights to environmental services were bestowed on the citizenry (Mishan, 1981:457-463).

Stone (1974) believes that natural areas and objects should themselves be invested with legal rights. While repairable damage to the environment might be balanced and weighed, irreparable damage could be enjoined absolutely. Perhaps it is possible to make new ontological distinctions, legally recognizing the essential interconnections between societies of men and societies of nature.

Spies (pers. comm.) suggests the proclamation of an environmental constitution which would safeguard especially valued but vulnerable environmental services. Constitutional protection for these key resources would serve to more effectively constrain policies, programmes and projects that might otherwise breach critical thresholds in the provision of those ecological processes and natural amenities which perform important life-support functions or enhance the quality of life. The object of such a constitution would be to minimize the risk of serious environmental degradation which could lead to "systems breakdowns" - ecological, economic, social and political - that might be uncontrollable and irreversible. Adoption of this suggestion would improve the prospects that mankind will survive, and that life will be rich and varied and eminently worth living.

Page (1977:xiii) advocates the use of market and microeconomic policy to achieve efficiency objectives, and macroeconomic policy and government intervention to achieve distributional objectives (both within and between generations). He suggests devising policy instruments, such as a severance tax, to keep the "real" price of vital materials constant or declining, and maintain valuable environmental services. This tax would, Page feels, impose little net burden upon the present generation but may have substantial effects on the condition of the resource base fifty years hence (Page, 1977:11).

Another general solution is to devise a simple set of rules which prescribe specific constraints on the efficiency objective (since it tends to dominate other objectives in individual analyses). For example, efficiency is to be maximized subject to the constraint that the people of a particular region or socioeconomic class must have their level of well-being increased, or that environmental quality, measured by some set of objective criteria, is not to be reduced (Herfindahl and Kneese, 1974:223; U.S. Water Resources Council, 1980). Failure to satisfy a critical criterion would result in rejection. Surviving alternatives could then be subjected to the evaluation procedure proposed in this dissertation (see Chapter 5). Thus, on a national level, resource managers would adopt the principles of "satisficing" rather than pursue a strategy of "optimizing" (Easton, 1973:78) in order to ensure that national policy objectives will not be violated in local assessments and decisions (see Political Rationality vs. Economic Rationality in Chapter 3).

The acceptance of such simple, broad-based policy constraints on resource usage can be a vitally important adjunct to the adoption of a method of formal evaluation (which is of necessity more narrowly focused) in achieving society's goals and objectives, but there is still the difficulty of determining what level of constraints to establish, and how to apply policy in a practical way to all conceivable situations. The establishment of specific thresholds for maintaining certain environmental services should be based on perceptions of risk, which should in turn be informed by the best available judgments as to the value and vulnerability of these services.

The first part of the problem of implementing a policy to maintain specified levels of various environmental services is to describe all the functions of natural systems which presently or potentially make significant contributions to social well-being, and the second part is to identify critical thresholds above which the various components of these systems must be maintained in order to ensure the continued provision of these welfare-inducing functions. The first problem is difficult enough, since ecologists have little understanding of the many complex interactions between organisms and their environment and the way in which these ultimately benefit man, and social scientists have not rigorously analyzed the way in which natural amenities contribute to individual and social well-being, or the importance of these contributions. But the second problem is even more daunting since it requires quantification of these poorly understood processes and effects, and the tools and methods of measurement used by ecologists and social scientists are not yet adequate to the task. Nevertheless, the problem is of such vital importance that it seems imperative to use whatever techniques and data are now available to estimate what these "critical thresholds" may be, and then promulgate "management thresholds" into which a significant safety margin has been built.

Supplementary Note

An Example of Planning Conservation Areas Through Resource Accounting

To illustrate the general approach that might be taken in developing a resource accounting system, an example will be presented related to the question:

> How much and what parts of South Africa's estuarine resources should be protected for their ecological and amenity values?

Estuarine systems are scarce resources in South Africa which confer many ecological and amenity benefits. In developing a resource accounting system to manage these resources, a team of ecologists - perhaps using Expert Systems or the Nominal Group Technique (see Appendix E, and Delphi and Nominal Group Technique in Chapter 3) - might first list the "vital areas", or subsystems, that form an integral part of and help define an estuarine system. Clark (1974:59) defines vital areas as "components of such importance to the functioning of the system that they must be preserved as intact units and given special protection from adverse influences". An example of a vital area would be a salt marsh. The next step would be to list the components of the subsystem; in the case of a salt marsh, this would include submerged grasses, certain species of euryhaline invertebrates, and juvenile marine fishes.

Then the team of ecologists would need to define the functions and potential uses of the components, subsystems, and finally the estuarine system as a whole. For example, <u>submerged</u>

grasses (one of the components) provide shelter for invertebrates and juvenile fishes, and produce detritus which constitutes the base of the food chain supporting large populations of filter and deposit feeders, estuarine fishes, and juvenile marine fishes. Salt marshes (one of the subsystems) produce detritus, store and regulate the use of water, store and cycle nutrients, trap sediments to prevent siltation downstream, process and assimilate civilization's wastes, buffer other components from floods, provide critical habitat for many species (breeding, feeding and nursery areas), and provide a unique recreational resource for human populations. Estuarine systems (the ultimate objects of interest) serve to maintain a dynamic equilibrium among coastal elements, play a role in biogeochemical cycling, are biologically highly productive (noted for high species diversity, richness, and biomass), provide critical habitat for rare and endangered species, offer opportunities for scientific research and specialized recreation, are aesthetically unique and add diversity to the landscape, and may have significant but as yet undiscovered functions and potential uses.

Once these functions and potential uses are identified and defined, the next step would be to inventory the country's estuaries, measuring and describing the components and subsystems which make up each estuary. In South Africa, much of this work has already been done (Begg, 1978; Heydorn and Tinley, 1980), and the Estuarine and Coastal Research Unit is compiling synopses of all available information on each estuarine system in the Cape Province.

Finally, an assessment would be made of the country's estuarine resource base, with the object of deciding

- which estuaries should be maintained as functioning estuaries, and
- at what level the various components and subsystems should be maintained in the selected systems to ensure that specific functions and potential uses of these estuaries would be conserved at reasonable levels.

One way to approach these tasks would be to conduct an Environmental Aspect Analysis (see Appendix AA for an example) to determine which elements in each estuary are of greatest conservation interest, and then to apply Expert Systems to make informed judgments directed at defining the relevant thresholds, and identifying the specific elements of the resource base to be conserved. Delphi procedures or Decision Analysis could also be used to accomplish this task, or to aid in the development of Expert Systems for managing resources. Other possible approaches that have been formulated include Integrated Resource Analysis (Norton and Walker, 1982) and resource accounting systems based on energy analysis (Slesser and King, 1988) or other key outputs of natural ecosystems (Odum and Odum, 1972).

The result of such an assessment would be the establishment of minimum maintenance levels for key resources and the delineation of "critical areas" to facilitate effective management of key resources. Once designated, a critical area would be afforded strict protection: no action would be permitted - regardless of how efficient (or otherwise desirable) it may appear to be - if that action would reduce the level of its components, or impair its functioning or alter its basic character, below the specified threshold levels (Oregon Land Conservation and Development Commission, 1976).

After management practices based on the threshold analysis have been developed, proposed actions that would affect estuarine systems could be assessed using Expert Systems. In some cases, a development project might be allowed if accompanied by a "shadow project", which either restored the area to its original condition after the project or else created a new area which performed the same role as the disturbed one (Pearce, 1988).

Finally, implementing the conservation policy could be entrusted to an independent Coastal Zone Advisory Board (Stauth, 1983b), which would have full responsibility for monitoring thresholds and the viability of critical areas. This Board could observe and record the cumulative and synergistic effects of past and present activities on estuarine systems by keeping track of various parameters which are good indicators of environmental conditions in critical areas; this information could then be used to control existing and future activities in such areas. The creation of such a Board would serve to compensate for the present diffusion of responsibility and incremental "ad-hocracy" in the management of estuarine resources, in which overall control of key environmental services is often effectively lost (Malan *et al.*, 1983).

APPENDIX H

INTEGRATED ENVIRONMENTAL MANAGEMENT

The Evolution of Integrated Environmental Management

In the early days of environmental assessment, environmental techniques were not directed at providing an input to the planning process, or to the implementation and management of a selected proposal. Environmental Impact Assessment was a reactive tool concerned only with critically investigating the environmental implications of proposals that were already in an advanced stage of formulation. As a result of its limited scope and essentially fault-finding character, Environmental Impact Assessment came to be seen as a negative process that caused great expense, trouble and delay of worthwhile development proposals. In addition, Environmental Impact Assessment was initially confined to assessments of specific projects and was not used to assess the sometimes more profound environmental consequences of policies and programmes.

By the mid-1970s, these limitations were being recognized in the United States; federal agencies began incorporating environmental investigations into their planning procedures and management plans, and started conducting Environmental Impact Assessments of policies and programmes (Lee, 1982). Nevertheless, the term Environmental Impact Assessment is still widely used in the United States and elsewhere in the original, narrow sense, and many people still view Environmental Impact Assessment as anti-development and not constructive. Therefore, in South Africa it has been decided to adopt a new term which more accurately describes this broader concept that embraces all aspects of environmental planning, assessment, decision making and management, and that refers to a general procedure for guiding and documenting all development decisions to ensure the protection and wise utilisation of the environment. The term which the South African Council for the Environment has chosen to describe this process is "Integrated Environmental Management".[1]

Integrated Environmental Management is concerned with all aspects and stages of environmental resource allocation, from conceptualization and planning, through assessment of effects, to the taking and implementing of decisions and monitoring of results. Integrated Environmental Management can be defined as a comprehensive decision-making framework and set of administrative procedures for improving resource allocation decisions and actions. Integrated Environmental Management is essentially an approach to information gathering and analysis which encompasses a broad range of methodologies such as terrain evaluation, ecological studies, Cost-benefit Analysis, Social Impact Assessment, Risk Assessment, Technology Assessment, and futures research. The object of Integrated Environmental Management is to ensure that environmental considerations are efficiently and adequately taken into account at all stages of the development process, and that key issues, judgments and decisions are clearly defined and communicated to all concerned.

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1 In 1984, the South African Council for the Environment established a Committee on Environmental Impact Assessment to recommend a national policy of environmental management. This committee co-ordinated a major research project which involved consultations with a broad spectrum of individuals and organisations throughout South Africa. Researchers also extensively investigated environmental management policy and procedures adopted by other countries, and produced a report which summarised the approach taken to Environmental Impact Assessment elsewhere (Schweizer, 1985). The committee then set about formulating the general principles and concepts of Integrated Environmental Management, and drafted a document recommending that Integrated Environmental Management be adopted throughout South Africa (S.A. Council for the Environment, 1989).

The General Approach to Integrated Environmental Management

The specific procedures used in the practice of Integrated Environmental Management will obviously vary according to the nature of the proposed action and the stage of its evolution, but the general principles and concepts of Integrated Environmental Management apply to all types of proposals using the same broad procedural framework. In order to clarify the nature of the Integrated Environmental Management process, and provide guidance for the practical application of specific Integrated Environmental Management procedures, it is necessary to first define the various categories of proposed actions that are encountered, the stages that these proposals normally follow, and the different classes of assessment that exist.

The Three Categories of Proposed Actions

All development and conservation proposals or actions can be classified into one of three categories, which form a natural hierarchy in environmental resource management.

1. Policies are declarations of general intent that guide the development of more specific actions.

2. Programmes are sets of plans or systematic actions for giving effect to policies.

3. Projects are discrete, highly-focused actions to meet more specific objectives.

For example, authorities might consider several different policy proposals for managing coastal zone resources. Once a coastal zone policy has been adopted, various conservation and development programmes would then be considered to implement the policy. Finally, specific conservation and development project proposals would subsequently be evaluated in light of the policy and programme objectives.

The Four Stages of Proposal Development

All proposed actions - whether they are policies, programmes, or projects - go through four identifiable stages in their development, from conceptualization through to implementation and management.

- The Proposal Generation Stage is concerned with developing and refining proposals for meeting some perceived need.

- The Assessment Stage is concerned with investigating and evaluating formal proposals. (The traditional focus of Environmental Impact Assessment, as the term implies, has been on the assessment stage.)

- The Decision Stage is concerned with identifying and formally selecting the alternative which is judged to be in the best overall interests of society.

- The Implementation Stage is concerned with ensuring that the preferred action is successfully implemented.

Evaluation takes place in all four stages. For example, in the proposal generation stage, the planner must evaluate the costs and benefits associated with various alternatives, and consider the value or worth of certain mitigation measures. In the assessment stage there is often an explicit (and always an implicit) evaluation of the significance of various impacts associated with a proposal. In the decision stage, an overall evaluation of the alternatives must be accomplished in order to make and justify the decision. Finally, in the implementation stage there is an ongoing evaluation of the effectiveness and adequacy of mitigation measures and other actions to judge whether any remedial actions are necessary.

The Three Classes of Assessment

Some proposals have more serious environmental implications than other proposals, and so warrant a more thorough environmental assessment. But in the early days of Environmental

Impact Assessment, relatively minor proposals were sometimes subjected to the same assessment procedures as major ones, and all aspects of the affected environment were often exhaustively documented even though it was apparent that many of these would not likely be seriously impacted, or were of little concern to anyone. On the other hand, some agencies subjected all proposals (even major ones) to a relatively cursory assessment, or gave inadequate attention to those impacts that were of greatest concern.

A central concept of Integrated Environmental Management is that some kind of "screening" procedure is needed to determine the appropriate level of assessment for a given proposal. The purpose of screening is to ensure that proposals with major environmental implications are properly assessed, but that time, money, and effort are not wasted on unnecessary investigations of proposals which will have no significant adverse impacts.

All proposals will fall into one of three classes, according to whether any significant impacts are likely to result.

- Class 1 proposals are those which clearly *will* result in significant environmental impacts
- Class 2 proposals are those which *may or may not* result in significant environmental impacts
- Class 3 proposals are those which almost certainly will *not* result in significant environmental impacts.

The screening decision, which is based on past experience and the use of screening guidelines, can generally be accomplished very quickly. A set of screening guidelines and sensitivity maps could be developed to assist authorities in making screening decisions. The screening guidelines would include lists of those actions which experience has indicated normally require Class 1 and Class 3 assessments. Such lists, and other aspects of the screening guidelines, would become more refined and useful over time.

Description of the Integrated Environmental Management Procedure

Figure H.1 illustrates the general Integrated Environmental Management procedure, and Figures H.2, H.3 and H.4 illustrate the specific procedures appropriate to each class of assessment. A brief description of each stage of the general procedure, highlighting some of the differences between the various classes of assessment, will be presented in what follows. (In order to simplify this presentation, the discussion which illustrates the procedure will be directed at the project category, although the general procedure is to be applied to programmes and policies as well as to individual projects.)

Proposal Generation Stage

From the moment a proposal is conceived it begins an evolutionary process in which it is modified and refined to make it more effective and acceptable. In the past, the environmental implications of a proposal were seldom considered during this early stage. The result was often a formal proposal that had adverse and sometimes unacceptable environmental implications. If environmental analyses by professional environmental scientists are done concurrently with planning and design activities, the proposal that is formally submitted will have a much better chance of being environmentally acceptable. Overall costs will also be reduced due to better planning, fewer delays, and more appropriate utilisation of resources.

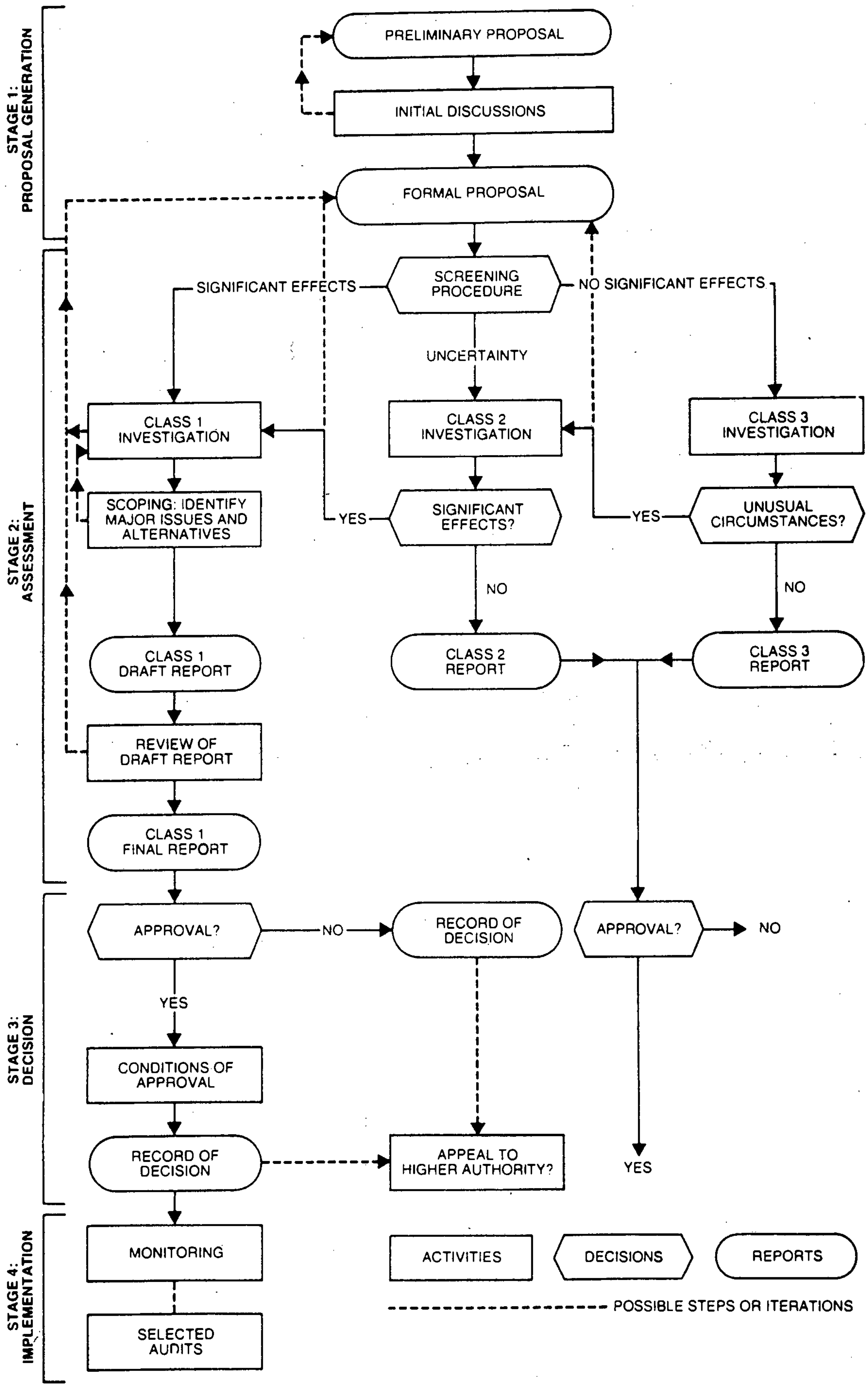
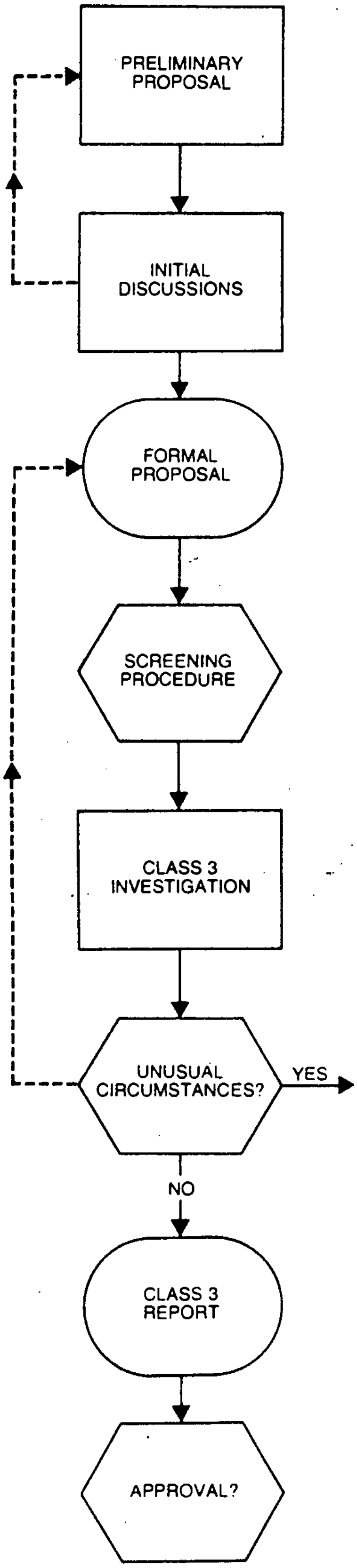


FIGURE H.1 Schematic Diagram to Illustrate the General Integrated Environmental Management Procedure (from S.A. Council for the Environment, 1989)



Proponent has an idea.

Proponent and relevant authority discuss how to improve the idea.

Proponent submits a proposal which describes the proposed action and alternatives.

Authority aided by screening guidelines determines that this action is of a type that normally does not cause significant environmental effects.

Proponent gathers sufficient data to determine whether any unusual circumstances exist.

If unusual circumstances are found which may cause significant environmental effects, the investigation is upgraded to a Class 2 assessment. Alternately, the proponent may choose to modify the proposed action for resubmission.

Proponent confirms there are no unusual circumstances which may cause significant environmental effects.

Authority decides whether to approve the proposal.

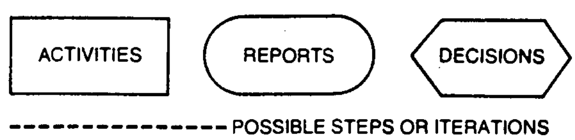
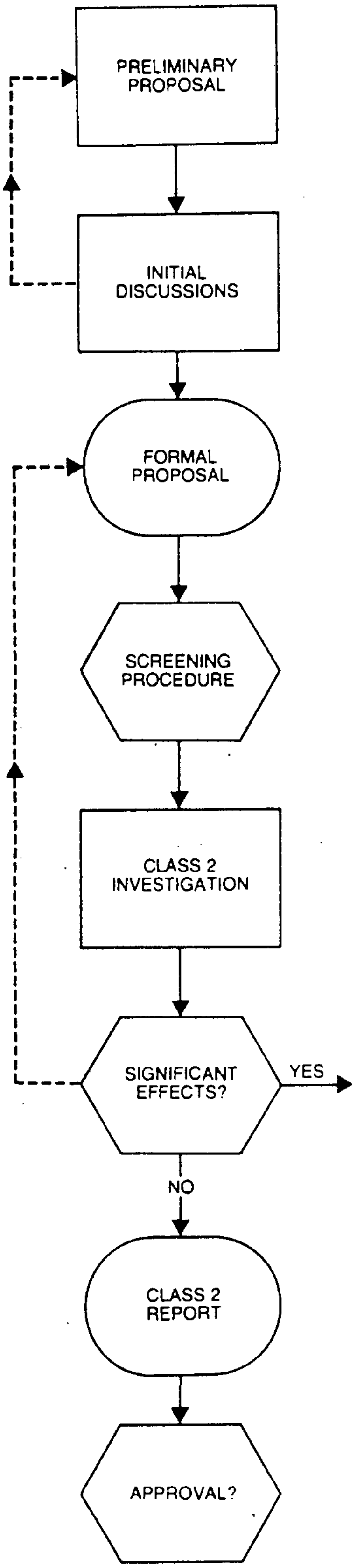


FIGURE H.2 **Procedure for Investigating Class 3 Proposals (from S.A. Council for the Environment, 1989)**



Proponent has an idea.

Proponent and relevant authority discuss how to improve the idea.

Proponent submits a proposal which describes the proposed action and alternatives.

Authority is uncertain whether there could be significant environmental effects.

Proponent gathers sufficient data to determine whether the proposal may have significant environmental effects.

If significant environmental effects are likely the proponent must proceed with a Class 1 level of assessment. Alternately, the proponent may choose to modify the proposed action for resubmission.

Proponent completes the Class 2 report with a formal "Finding Of No Significant Effects" (FONSE).

Authority decides whether to approve the proposal.

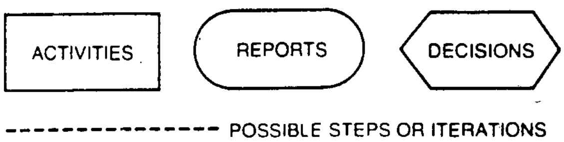
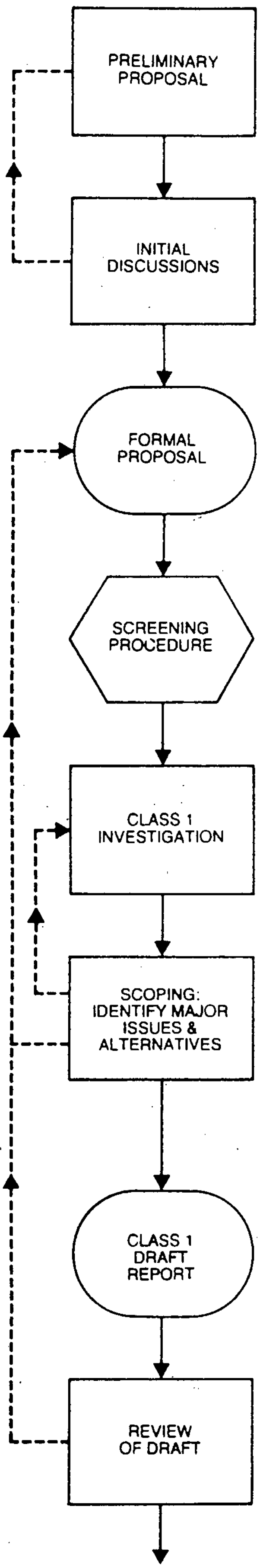


FIGURE H.3 **Procedure for Investigating Class 2 Proposals (from S.A. Council for the Environment, 1989)**



Proponent has an idea.

Proponent and relevant authority discuss how to make the proposal more environmentally acceptable, and explore possible alternatives to the proposal.

Proponent submits a proposal which describes the proposed action and alternatives.

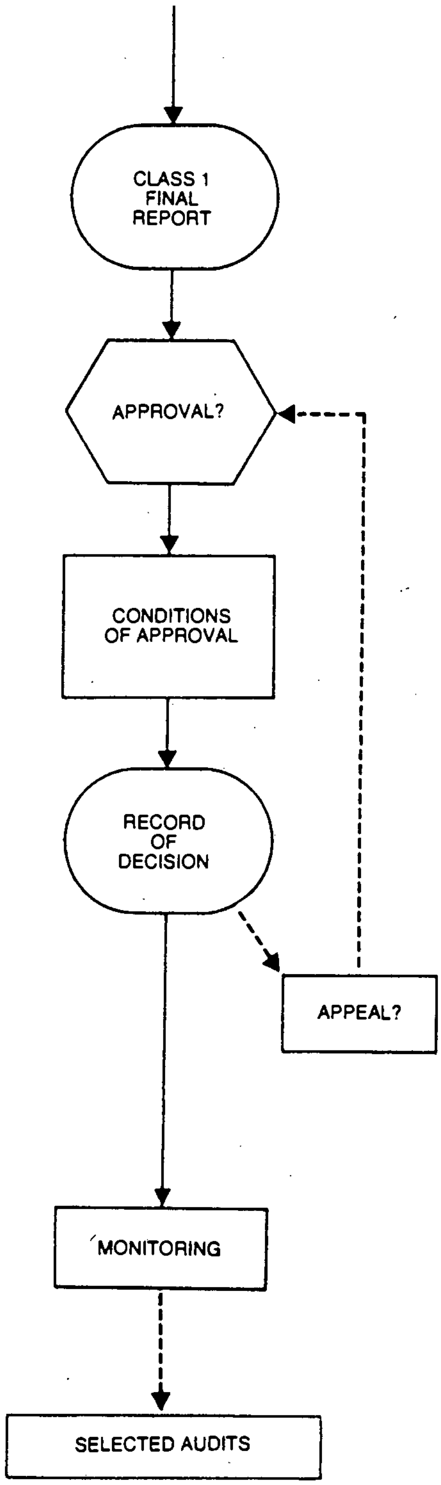
Authority aided by screening guidelines determines that this action will have significant environmental effects and therefore a Class 1 assessment is necessary.

Environmental effects of proposed action and major alternatives are investigated.

Affected publics are asked what their concerns are. Officials from local, regional, provincial and central government help identify the important issues. Alternative proposals are solicited. Proponent may decide to modify the proposed action for resubmission.

Environmental effects or proposed action and major alternatives are documented.

The draft report is made available for public comment, and may be reviewed by an impartial body for adequacy and completeness. Proponent may decide to modify the proposed action for resubmission.



Report is revised in light of the comments received.

Authority decides, considering environmental and other criteria, whether to approve the proposal.

If approved, measures required to reduce adverse effects are specified. An environmental management plan may be required.

Authority writes a short clear report, for public disclosure, recording the decision and on what basis it was taken.

If either the proponent or the affected public feel aggrieved they may appeal to higher authority.

A close watch is kept on whether the proponent is adhering to the management plan or observing the mitigation measures and any other conditions of approval.

Some actions are reviewed after a period of time has elapsed to suggest how the IEM process might be improved.

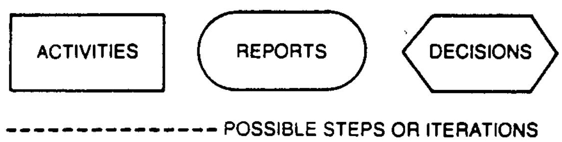


FIGURE H.4 **Procedure for Investigating Class 1 Proposals (from S.A. Council for the Environment, 1989)**

The proposal generation stage should begin with informal discussions between the proponent and the authority who is charged with responsibility for granting or denying approval. These discussions would allow the proponent to clearly explain to the authority the purpose and need for the proposed action, and give the authority an early opportunity to suggest to the proponent ways in which the action might be made more socially and environmentally beneficial. No expensive plans or formal documentation should be required during these initial discussions; this will help to ensure that the proponent does not become committed to a specific course of action until he has had an opportunity to consider possible objections on environmental or other grounds and consider alternative ways of meeting the purpose and need of the proposed action.

The tasks to be accomplished during the proposal generation stage will differ according to whether the proponent is from the private or public sector. Private sector proponents should use this stage to gauge, through interactive consultation with authorities and concerned parties, the general desirability or acceptability of the proposed action in relation to relevant planning guidelines, structure plans and other development criteria. This may result in one or more alternatives to the original proposal.

Public sector proponents (and private sector proponents utilizing public land) should be required to actively seek and consider viable alternatives for meeting the purpose and need of the proposed action. These alternatives may be fundamentally or incrementally different in character. Alternatives can then be compared and a judgment made as to which are most promising and deserving of a formal assessment.

Assessment Stage

The assessment stage is reached when the final version of the proposed action (along with any alternatives) is made ready for submission to the relevant authority. There is, however, an important feedback loop to the proposal generation stage since this formal assessment may suggest further modifications to the proposed action. The assessment stage culminates in the production of a report that documents the results of the assessment.

If the planning process in stage one has had adequate environmental input, the final versions of the proposed action and its alternatives will - to the extent that is practicable from the point of view of the proponent - minimize those environmental effects which are adverse, and enhance those which are beneficial. This will simplify the assessment process, and in fact the environmental report required at the end of stage two may contain environmental analyses already done during stage one.

It is recommended that the proponent be held responsible for the entire environmental impact analysis process (*viz.*, preparation and adequacy of all investigations and reports associated with the proposal assessment stage). The final environmental report will present, in an appropriate level of detail (depending on the class of assessment), a description of:

- the reason for the proposal;
- the proposed action and, for public sector proponents, alternatives to this action (to include, as a minimum, the alternative of taking no action);
- the affected environment;
- potential environmental impacts and who would be affected; and
- possible measures to mitigate adverse impacts.

The assessment stage need not be a costly or time-consuming process. To avoid unnecessary expense and effort, it is important that the relevant authority employ the aforementioned screening procedure to sift out those proposals which experience has shown do not normally result in significant environmental effects, or which may require only a brief investigation, so that relatively simple and straightforward assessments can be done for such proposals. The following sections briefly describe the differences between the three classes of assessment.

If the proposed action is one that, according to the screening guidelines, normally requires a Class 3 assessment, only a very perfunctory investigation need be done. This is simply to determine if there are any unusual circumstances surrounding the proposal which might require that the investigation be upgraded to a Class 2 assessment. If there are no unusual circumstances, then a Class 3 report would be completed and submitted to the relevant authority; otherwise, a Class 2 assessment would be conducted (see Figures H.1 and H.2).

If the proposed action is not one that, according to the screening guidelines, generally requires either a Class 3 or a Class 1 assessment, then a Class 2 assessment is conducted to determine whether any significant environmental consequences might result from the action. If there is a finding that in fact no significant effects would occur, a Class 2 report would be completed and submitted to the relevant authority. If, on the other hand, it is determined that at least one significant adverse effect is likely to occur, then the investigation would be upgraded to a Class 1 assessment (see Figures H.1 and H.3).

In the event that the screening procedure or Class 2 assessment indicates that the proposed action would have significant adverse environmental consequences, a Class 1 assessment is done. This class of assessment requires "scoping", a procedure which is initiated as soon as the screening decision is made. As the term suggests, scoping is concerned with limiting the scope of the assessment by early identification of the potentially significant impacts, and suggestions as to how these could be avoided or mitigated while still meeting the purpose and need of the proposal. Scoping is directed at involving affected publics as well as any authorities that may have jurisdiction or expertise relevant to the proposal. The object of scoping is to clearly identify and focus the assessment on the truly major issues involved, and to search for viable alternatives or ways to make the proposed action more acceptable.

For Class 1 proposals, it is also important to provide for an ongoing review procedure to improve the analysis, ensure that the assessment is responding to genuine concerns, and encourage the development of compromise solutions and mitigation measures. For proposals which are particularly complex, involving a major allocation of resources, and which could result in especially significant impacts, a "*scoping committee*" comprised of persons with special expertise relevant to the proposal should be appointed early in the assessment process to guide the assessment and suggest ways of improving the proposal as new information is obtained.

After the Class 1 assessment is completed, interested parties should be given an opportunity to comment on the draft environmental report, which is prepared at the end of the assessment process. Comment on the draft environmental report is to be solicited from members of the general public and special interest groups, as well as from government bodies and other authorities. The object of seeking comment on the draft environmental report is to ensure that all concerns have been heard, understood and addressed before the final environmental report goes to the relevant authority and a decision is made. In addition, the draft report should be reviewed for adequacy and completeness by an impartial person or panel with special expertise in environmental impact assessment. After all comments are considered, the draft report is revised and a final report prepared (see Figures H.1 and H.4).

It is anticipated that many proposals will be assessed at the Class 3 or Class 2 level, thus reducing the cost and complexity of applying the general Integrated Environmental Management procedure. For example, a Class 3 assessment might be completed in one or two days using a checklist on a preprinted form, while a Class 2 assessment would normally require an investigation that could be completed in perhaps one or two months by obtaining readily available information from secondary sources and using the telephone to consult knowledgeable parties. Reports documenting these two classes of assessment should be very concise and easy to compile. In fact, the entire Integrated Environmental Management process can be made very simple and routine for these two classes of assessment, and it should be possible to develop, for each of these two types of proposal, an administrative procedure and documentation format that would combine all requirements for the assessment, decision, and implementation stages of Integrated Environmental Management.

Class 1 assessments will of course be the most time-consuming and costly to complete. In order to make the assessment process cost-effective, guidelines should be developed for document length and completion time. It is envisaged that a Class 1 report should normally consist of less than 150 pages and be completed within one year.

Decision Stage

The general task of the decision stage is to identify and formally approve the action that is in the best overall interests of society. When the relevant authority has the appropriate environmental report, he will make his decision whether to approve the proposed action, grant conditional approval (subject, for example, to the satisfactory implementation of certain mitigation measures), or reject the proposed action on environmental or other grounds and adopt some other alternative (including, for example, the null alternative, or maintaining the status quo).

If approved, there may be a requirement for a management plan, or the appointment of a person charged with monitoring and managing environmental impacts (an "environmental impact control officer"). The management plan is to describe how the action will be implemented in an environmentally sensitive way, and indicate how any required mitigation measures will be carried out; it should also establish a procedure for monitoring the success of these measures, detect any unforseen environmental consequences, and respond to environmental problems that may arise.

If the alternative selected is likely to result in significant impacts which cannot be fully mitigated, then the decision maker has a special responsibility to explain his decision to the public. The decision should therefore be formally recorded in a document which explicitly states what the alternatives were, what alternative has been selected, and how environmental considerations were taken into account and weighed against other considerations in making the decision. The record of decision should be made available on request to any interested party in order to make the decision making process as open and accountable as possible.

A brief but formal explanation of the decision will help avoid the misunderstandings, mistrust and rumours that often follow announcements of major decisions, and will make decision making generally more open and accountable, in conformance with the ideals of a democratic society. This would have two desirable effects:

- Public officials would be encouraged to consider social welfare criteria more explicitly, and to develop effective procedures for applying these criteria.

- The general public would then have a clear record for rationally assessing the performance of its elected or appointed officials.

Finally, a clearly defined procedure should be developed for appealing against a decision. It is recommended that there should be time limits placed on both the filing of and ruling on appeals, and that the costs of appeal should be borne by the party that appeals the decision if the appeal is not successful.

Implementation Stage

For any action that has been approved in principle, some provision should be made to ensure that all conditions of approval are met. For those cases in which a permit is necessary, there may be stipulations attached which must be observed for the permit to remain valid. A monitoring programme will be needed to ensure that mitigation measures are being taken and are proving effective, and to ensure that unforseen impacts will be detected and properly treated. If a management plan has been required, the relevant authority will need to develop some cost-effective way to supervise the application and success of the management plan.

In addition, the authority should occasionally audit Class 1 actions after they have been fully implemented in order to assess how effective the management plan has been, and to gain insights as to how the entire Integrated Environmental Management process can be improved.

Proposal Generation and Assessment for Class 1 Proposals

This section explores in more detail how the Integrated Environmental Management procedure can be applied to Class 1 proposals, and analyzes more closely the relationship between the proposal generation and assessment stages. This section is also intended to clarify what is involved in each of these two stages, which are both directed at improving resource allocation decisions, and to indicate how this general research methodology for environmental evaluation can be applied to specific tasks.

The Link Between Proposal Generation and Assessment

Resource allocation actions are not normally the product of a single decision, but result from a whole series of decisions taken by a number of people during the Integrated Environmental Management process, from the proposal generation stage through the implementation stage. In fact, the "final decision" that is taken in the decision stage by the authority with ultimate decision making responsibility is really only a choice between a handful of the hundreds of possible alternatives (that differ in some fundamental or incremental way) for meeting the purpose and need of the proposal. These final alternatives have been selected and shaped by planners, engineers, environmental analysts and other professionals during the proposal generation and assessment stages.

One of the major differences between planning and assessment is that the assessment stage is intended to provide a far more detailed examination of the environmental implications of the proposal(s) than would have been done in the proposal generation stage. But there is considerable overlap in the functions of environmental planners and environmental analysts. For example, environmental planners must search for alternative solutions to a problem, but then environmental analysts also have a responsibility to consider alternatives that should be assessed. In addition, both need to forecast potential impacts and consider the nature and possible significance of these impacts, and what can be done to mitigate them. While this may seem confusing and somewhat inefficient, particularly because of the interactive and iterative nature of environmental planning and environmental assessment, it is eminently desirable that certain critical tasks are repeated by different persons because of the different responsibilities and perspectives of the environmental planner and the environmental analyst. Normally, for Class 1 proposals, more than one person will be involved in each of these tasks; for convenience these "groups" will hereinafter be referred to as the "planning team" and the "assessment team", and team members will be referred to as "planners" and "analysts" respectively.

There are several reasons why it is advantageous to maintain a clear distinction between the planning and assessment processes, and to have two different teams responsible for their accomplishment. For one thing, the fundamental nature and orientation of these two processes are very different, and require a different mindset and different types of procedures. The planning team is charged with a highly creative task, whereas the assessment team faces an analytical task, and different talents and approaches are needed for these different tasks.

In addition, planners will naturally feel compelled to defend their ideas and may therefore be blind to weaknesses and shortcomings in their proposal, while the analysts will have more open minds and can offer a fresh perspective and valuable insights into the merits of the proposal (and whether it can be improved or should be rejected in favour of some alternative proposal). Presumably if the planner could see the problems with his plan he would have corrected them (or adequately explained the reasons why they could not be corrected) before the plan was submitted as a formal proposal; it is very difficult to critically assess one's own plan, or be impartial when comparing one's own plan to some alternative.

Finally, the planner is primarily interested in furthering the interests of the proponent, and will therefore be less inclined to pay sufficient attention to other interests. The analyst, by contrast, has broader responsibilities, and can devote more of his energies to examining the implications of the proposal for other groups.

It is therefore extremely useful and productive to have one team, with no vested interest in a particular proposal, to critique the work of the team that is responsible for developing the proposal. Although there is obviously potential for conflict between these two groups, a cooperative attitude can and should be cultivated, and close working relationships should be fostered and maintained.

Proposals with major environmental implications should, therefore, normally be formulated and planned in some detail during the proposal generation stage by one team, and then assessed by another team in the assessment stage. There are two general approachs for relating the work done by the planning team to that done by the assessment team. One approach - which is that adopted in the early days of Environmental Impact Assessment - is to have the two teams work sequentially and in relative isolation, so that the planning team produces a detailed proposal, accompanied by expensive design drawings and other supporting materials, that is then handed to the assessment team so that it may undertake an independent investigation of the proposed action and produce a detailed report on its environmental implications. This approach has a confrontational aspect and obviates finding ways to improve the proposal and reconcile potential differences before expensive commitments are made to one course of action.

The other approach - which is in conformance with the principles of Integrated Environmental Management and political rationality (see Political Rationality vs. Economic Rationality in Chapter 3) - is to have the two teams work together closely and undertake several iterations of planning and assessment in order to develop and improve one or more proposals before submission to the authorities in the decision stage. Environmental planners should obviously be part of the planning team from the very beginning of the proposal generation stage, and once there is some specific proposal to assess, environmental analysts should continually feed back the results of their assessments to the planners so that plans can be continually improved. Ideally, then, there is a positive feedback loop between the proposal generation and assessment stages, involving multitudinous decisions resulting from the interactions between two multidisciplinary teams as they undertake an iterative process of formulating and testing new ideas as new data arises.

The Proposal Generation Stage

Proposal generation is essentially a planning function - it is concerned with identifying the most socially desirable alternatives for utilizing the resources of an area, or for accomplishing some prescribed objective or set of objectives. This involves, among other things, an examination of existing and potential resource allocation patterns in the area of concern, an analysis of wants and needs, and a creative search for ways to meet those wants and needs in an optimal (or at least more satisfactory) manner.

These investigations are scaled to suit the probable importance of the resource allocation decision and the availability of time, money and manpower to the planners. Emphasis will usually be on considering the implications of alternatives that have already been motivated by interested parties, such as private land owners or public authorities, but an attempt should always be made to suggest how these proposals could be improved, identify new alternatives, and possibly resolve conflicting interests by devising some compromise plan that would be acceptable to all parties. Rational planning is concerned with solving problems rather than simply promoting an idea or object: it is vitally important to first elucidate the problems that are to be solved, and then to ensure that all possible alternative solutions to each problem are identified and given proper consideration (Brooks, 1976:124-125).

Once a comprehensive range of alternatives has been identified, some procedure is needed to evaluate their viability and decide which should be subjected to closer scrutiny. The selection of "*final proposals*" - those which will be put forward for formal assessment - should normally be accomplished in consultation with affected parties and appropriate authorities, using formal and informal techniques for judging the relative desirability of the various major alternatives. The objective of this phase is to reduce the number of alternative plans to more manageable proportions (preferably to two or three) in order to permit detailed assessments and evaluations to be accomplished at a reasonable cost.

The problem of deciding what alternative proposals should be fully developed and subjected to a detailed analysis is a major consideration which has not been adequately addressed by many formal environmental evaluation methodologies. The development of strategies that direct attention to the factors judged to be most critical in distinguishing likely alternatives is a subject that has been almost completely overlooked in the formal evaluation literature, yet the function can be crucial (McAllister, 1980:272). Very often it is left to the individual planner to "think up" possible alternatives to a proposal, and this narrow and unsystematic approach to generating alternatives must often result in sub-optimal solutions to resource allocation problems. Optimal resource allocation plans are not likely to be achieved if not all alternatives are known; the search for alternatives is therefore of considerable importance (Kassouf, 1970:85-86).

There are two major classes of alternative proposals (Easton, 1973:81): those which are disparate or fundamentally different (*i.e.*, members of a heterogeneous class), and those which are discrete or incrementally different (*i.e.*, members of a homogeneous class). The difficulty is that between these two classes there are virtually an infinite number of potential solutions to a set of problems, since for each proposal which is fundamentally different (and there may be a great many of these), there are a host of variations which are incrementally different, each having different implications for social well-being (Matthews, 1975:128). To attempt to precisely identify and then rigorously plan or assess all possible alternatives would obviously be impractical, but several techniques have been developed to aid in the identification of the most promising alternatives. Once identified, these final proposals can then be subjected to the full planning and assessment procedures.

The two key steps in the proposal generation stage - identifying a wide range of possible plans, and then selecting a few for detailed planning and assessment - require the clear definition and application of evaluation criteria. Planners should search for alternatives which will resolve resource allocation problems in ways that are efficient, fair and sustainable. While other, more specific, criteria might also be formulated to provide guidance in the selection of alternatives, all should in some way be related to these three more general criteria (see Defining Evaluation Criteria in Chapter 4).

The problem of generating suitable alternatives has no straightforward solution (Green and Tull, 1978:22-23). Generally, one or more alternatives will be given by the owner, developer or managing authority of the resources in question, since projects are normally initiated at the request of an interested party who has some specific suggestion as to how the resource should be utilised. Once initial suggestions have been investigated, a search for variations of these proposals (through, for example, the adoption of certain mitigating measures), as well as for completely different alternatives, should begin. General approaches to this task include (Easton, 1973:88):

- relying on one's own experience;
- conferring with colleagues;
- consulting experts;
- reviewing research reports;
- establishing a task force to gather new data and explore new ideas; and
- surveying interest groups or the general public.

Common sense, insight, and good judgment must play a role in any approach.

Current approaches to forecasting the possible effects of alternative actions are weak, and if forecasts are to be useful and defensible, a more systematic approach is needed (Duinker, 1986). At the heart of this all-important task of searching for reasonable alternatives is the art of forecasting. Armstrong (1985:14) suggests that this art can be made into something more of a science by using a systems approach to forecasting, which involves the following steps:

- identify objectives,
- describe the system,
- devise strategies,
- evaluate strategies, and
- select strategies.

Planners must first clearly identify their intentions (*i.e.*, what events do they want to control?) and then consider the possible outcomes of pursuing these intentions (*i.e.*, what events could occur that may not be under one's control?). Due to the complexity of the task, it is advisable to use more than one approach to forecasting and then combine the forecasts. Some of the different approachs to forecasting are: judgmental methods; bootstrapping; extrapolation methods; econometric methods; and segmentation methods.

If using more than one approach, Armstrong (1985:272) suggests the following order (see Figure H5):

- subjective methods before objective methods, and
- segmentation before extrapolation or econometric methods.

Subjective or judgmental methods involve three steps:

- select judges;
- pose questions; and
- obtain forecasts.

Expert Systems (sometimes called "bootstrapping) is a subjective method that is made more objective by providing a means of objectively applying subjectively-determined rules. This technique combines the strengths of the subjective and objective approaches to forecasting because rules for forecasting events are <u>formulated</u> using the subjective method, and then the rules are <u>applied</u> using the objective method. The first is a complex task, involving intuitive as well as analytical reasoning, and this is what true experts are good at doing; the second is a straightforward but tedious task, and models are better than experts at doing this because they do not tire or get emotional or have their attention diverted or get fixated on any of the elements while applying the rules in a logical way. Thus, the forecaster can build a model that is better at forecasting than he is - hence the term "bootstrapping".

Potential sources of error in building an Expert Systems model are bias (from being too close to or affected emotionally by the situation) and "anchoring" (from having a rigid outlook or preconceived position - usually a "conservative" view). Both of these problems can be substantially ameliorated by engaging several experts and using an iterative procedure with feedback, such as the Delphi method, in building the model.[2]

2 See Appendix E for a fuller discussion of Expert Systems.

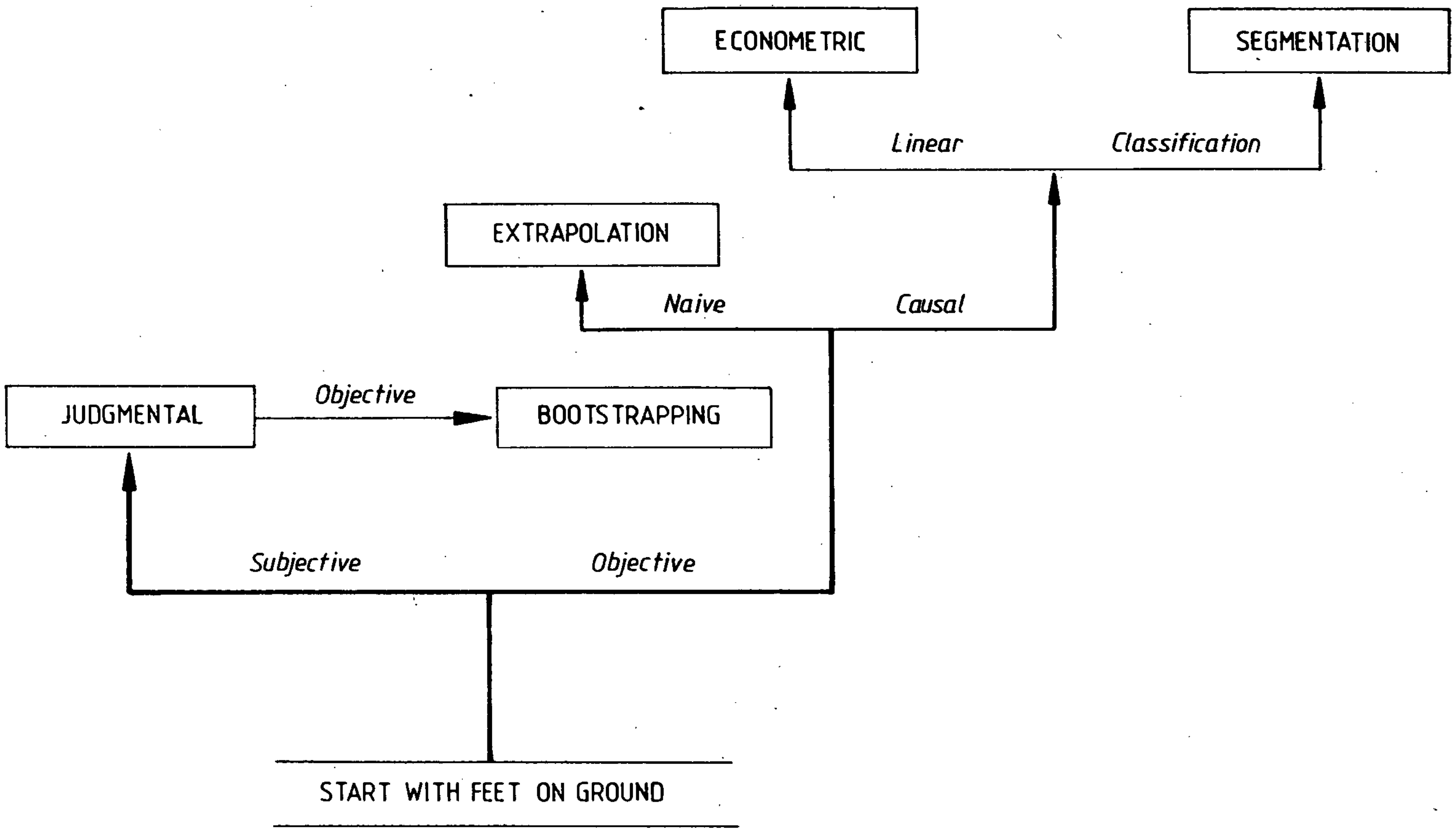


FIGURE H.5 **Forecasting Methodology Tree (from Armstrong, 1985)**

Several group techniques can be used to generate alternative plans (Burton, undated):

- Formal or informal committees can be organized to exchange ideas and make recommendations for plan definition.

- Discussion groups offer a more relaxed and unstructured approach to formulating plans by consensus; discussions can be made more effective if each participant prepares a written statement for discussion and then makes notes of the group's suggestions for modifying the plan.

- Brainstorming promotes a free and uninhibited atmosphere for generating ideas; spontaneity and creativity are encouraged by prohibiting formal judgments and judicial evaluations, and participants are asked to try to integrate and improve on ideas previously suggested.

- The Nominal Group Technique[3] is a highly structured, non-interactive process which can be adapted to the formulation of plans or major components of plans. For example, each participant can list his ideas on a piece of paper. The group facilitator then asks each participant in turn for one idea, recording the ideas on a master list, and continuing the process until all the ideas have been recorded. Each participant then selects the ideas he feels are best and writes them down in order of importance. The resulting lists are combined and a group-preference list is derived. This list can then be discussed, and ideas modified, to produce alternative plan descriptions which can be submitted to a final vote.

Group techniques can also be used to select the final proposals for assessment, but the problem of merit-ordering a set of alternatives is more amenable to mathematical treatment and several special methods and techniques have been devised to deal with it (see, for example, Appendix D and Special Methods in Appendix A). Most of these approaches involve the weighting of criteria and the adoption of simple decision rules for rejecting or accepting each alternative. For example, one simple approach is to establish minimum requirements for satisfying each criterion, and then eliminating those which do not meet the prescribed standards and selecting the best of the survivors according to the weighted sum of quality points (Easton, 1973:270). This approach could be useful if policy constraints were placed on the utilisation of selected environmental services as suggested previously (see Appendix G). Another approach is to apply different sets of weights to the criteria which reflect the preferences of different interest groups, and then selecting as the final proposals those alternatives which receive consistently high rankings (Easton, 1973:298).

Techniques for merit-ordering of alternatives generally involve a vector-to-scalar transformation to construct a single index-number that can be used thereafter as a figure-of-merit. Unfortunately, different mathematical operations can give different rankings of alternatives (Easton, 1973:172). Another major difficulty with merit-ordering techniques in general is that it is extremely difficult to weight criteria without reference to specific changes in outcomes in terms of the criteria. Simply saying that criterion A is 2.4 times as important as criterion B disregards the fact that utility functions may vary from situation to situation and may increase or decrease at different rates according to a number of context-specific variables.

Nevertheless, some criterion weighting and merit-ordering techniques appear to be useful tools for reducing the number of alternatives to be considered (Easton, 1973:183-216). No matter which technique is used, sensitivity analysis should always be performed to discover just how sensitive is the ranking of alternatives to small changes in criterion weights (Easton, 1973:302).

Criteria weighting can be done in several ways. For example, one method is to first rank the criteria, and then place each criterion in order of importance along a scale from 0-100 which

3 See Delphi and Nominal Group Technique in Chapter 3 for a fuller discussion of this technique.

constitutes a ratio chart (the most important criterion entered at 100, the second most important entered against the number which reflects its ratio of importance to the first, etc.). Another method is to use a scaling factor derived by conceiving a pair of equally attractive alternatives scored on two criteria, preferably the least and most important; intermediate criteria are then weighted by linear interpolation, making adjustments by comparisons of criteria of adjacent rank (Easton, 1973:295-296).

Many techniques for identifying leading alternatives are based on one or more of the group of analytical procedures which grew out of Operations Analysis, such as Systems Analysis and Decision Analysis (Raiffa, 1968:295). One possible application of Decision Analysis (see Appendix D) in narrowing the range of alternatives would be to ask natural antagonists (groups with different value systems or interests who are advocating mutually-exclusive alternatives) to use this technique to systematically explore the range of discrete (or incrementally different) alternatives in which they may be interested. Each group could use a Decision Analysis technique appropriate to the level of resources available to come up with the alternative which would maximize its expected utility. In this way the proponents of disparate (or fundamentally different) alternative plans could systematically and rationally narrow the range of alternatives to be finally considered by the decision makers.

Massam and Askew (1982) have conducted a thorough evaluation of several major techniques for identifying leading policy alternatives. These techniques could also be applied to alternative programmes and projects. The techniques evaluated were structural mapping of indifferences, utility values, lexicographic ordering, factor analysis, concordance analysis, and multi-dimensional scaling. The aim of these is

> to present a set of better policies from a larger set of feasible alternatives. As such the methods should be seen as sieving devices for reducing the set of possible alternatives, rather than as a means of identifying the best policy. The most appropriate method needs to be comprehensive, systematic, simple and quick, and be an aid in the decision making process, not a means of making the decision. It is suggested that concordance analysis and multi-dimension scaling meet these criteria.... [The concordance analysis technique is preferred because it] is objective, permits incommensurable scales, and utilizes all the data given. It allows sensitivity analyses to be easily included through varying different aspects of the procedure, and presents the set of best policies in a way that indicates the relative attractiveness of all the policies (Massam and Askew, 1982:203)

Formal techniques for evaluating and eliminating the number of alternatives to be considered can greatly assist in the identification of a set of preferred alternatives, but they are not essential. What is more important is making a commitment to the search for alternatives, and ensuring that the quality of investigations are to a high standard. The human mind is, after all, capable of storing and processing huge quantities of information, and therefore simple human judgments can be relied on to select the proposals most worthy of assessment provided that these judgments are made within the framework of a procedure which is conducive to rational analysis.

The Assessment Stage

The terms "Environmental Impact Assessment" and "Environmental Impact Analysis" are often used interchangeably in the literature (and both designated by the acronym "EIA") to refer to the process of gathering and analyzing data pertaining to the potential environmental consequences of taking some action (Schweizer, 1985:7-11). In this dissertation the term Environmental Impact Assessment has been used to refer to the administrative process by which the environmental impact of a proposal is determined (Fuggle, 1983:488).

The Distinction Between Assessment and Evaluation

Environmental Impact Assessment is primarily concerned with forecasting what might happen if a given action is taken or not taken, and describing these forecast outcomes in sufficient detail to permit decision makers and concerned parties to judge their social significance. An Environmental Impact Assessment may or may not be concerned with making explicit evaluations of the social significance of alternative actions, or of any of the forecast outcomes associated with these actions; therefore, a distinction can and should be made between environmental assessment (or analysis) and environmental evaluation. Evaluation has been described as the process of obtaining, organizing and weighing information on the consequences, or impacts, of alternatives (McAllister, 1980:3). Environmental Impact Assessment, on the other hand, is more narrowly concerned with the systematic collection and interpretation of data so that alternatives can then be "weighed" and trade-offs made. Environmental Impact Assessment is certainly concerned with "obtaining" and "organising" information, but not necessarily with explicitly "weighing" that information; nevertheless, its primary object is to assist decision makers in accomplishing for themselves this difficult task of evaluation.

Environmental Impact Assessment has been defined by Munn as an activity designed to identify and predict the impact on man's health and well-being of legislative proposals, policies, programmes, projects and operational procedures, and to interpret and communicate information about the impacts (Munn, 1975:23). The object of Environmental Impact Assessment is thus to provide the information that is necessary to conduct an evaluation of the environmental implications of a proposed action. Environmental evaluation obviously occurs during the assessment stage of Integrated Environmental Management (though not necessarily explicitly), but it also takes place in the proposal generation stage and is - most importantly - the culmination of the planning and assessment process in the decision stage of Integrated Environmental Management.

The distinction between Environmental Impact Assessment and environmental evaluation is not just an academic one: some Environmental Impact Assessment techniques require the environmental analyst to make value judgments which may be beyond his competence and these judgments may not be accepted by decision makers or other concerned parties; this can cast a pall over the entire Environmental Impact Assessment process, and diminish the credibility and usefulness of the Environmental Impact Assessment report. In addition, decision makers normally do not want the evaluation done for them; they simply want enough information provided in the Environmental Impact Assessment so that they can evaluate the environmental consequences for themselves (Bisset, 1980:37-38).

Finally, formal evaluations employing elaborate or sophisticated techniques are not always practical or appropriate, particularly in Third World countries; there seems to be little point in going to great trouble and expense if proposals are not particularly controversial, or if they can be made more acceptable by employing the principles of political rationality (see Political Rationality vs. Economic Rationality in Chapter 3). On the other hand, comprehensive and explicit evaluations are more useful (and often desired by decision makers) for controversial resource allocation proposals because some attempt at applying the principles of economic rationality can help defuse emotional antagonism and mistrust, and persuade anxious individuals who are party to the conflict that an open, independent and objective evaluation will be done (see Chapter 5).

In most cases, it is possible to find a way to accomplish the objectives of the proponent in a way that is acceptable to all affected parties, provided that planners, analysts and decision makers follow the principles of Integrated Environmental Management. It is only when serious controversy and irreconcilable proposals are involved that it is advisable to go further and supplement the assessment with a formal evaluation (see Formal and Informal Evaluations in Chapter 2).

The basic approach to assessment in the Integrated Environmental Management procedure is the same irrespective of whether provision is made for some formal method of evaluation. In other words, there are certain principles which should always be observed in undertaking an assessment, and then if a proposal is judged to be particularly significant and controversial, one can incorporate formal evaluation procedures as required. Since Chapter 5 presents a method of formal evaluation for controversial resource allocation proposals, the following discussion will be confined to an examination of the general approach to Environmental Impact Assessment when a formal evaluation procedure is not deemed necessary.

Assessments Employing Informal Methods of Evaluation

The assessment stage of Integrated Environmental Management begins when there is a clearly defined proposal to assess. Data acquired during the assessment stage may be expected to result in substantial modifications to the proposed action or its alternatives, and new, more promising alternatives may be discovered. In fact, the emphasis in Environmental Impact Assessment should always be on finding ways to reduce the undesirable effects of the proposed action to make it more acceptable to concerned parties, and the assessment stage is to be seen as a helpful, constructive process to assist proponents in accomplishing their objectives in an environmentally-acceptable way. Perhaps the vast majority of conflicts in environmental decision making can be significantly ameliorated, or even completely resolved, through compromise and mitigation. The Environmental Impact Assessment can play a vital role in attaining this much desired result by providing information needed to understand the full biophysical and socioeconomic consequences of proposed actions, and by suggesting more acceptable alternatives or remedial measures.

To this end, as previously mentioned, there is an important feedback loop from the assessment stage to the proposal generation stage, and this loop should be activated whenever the assessment process reveals new information relating to the general viability or acceptability of the actions under consideration. Therefore, it is important that the assessment team has ready access to the planning team so that as potentially significant adverse impacts are identified, the planners have an opportunity to either present a new proposed action or modify the original proposed action to avoid or mitigate these impacts.

If the proposed action is determined by the screening procedure to be a Class 1 proposal, then public and authority scoping are to be initiated at the outset to identify the major issues that should be addressed, and solicit suggestions as to what other alternatives should be considered in the Environmental Impact Assessment report. Every attempt should be made to fully involve all affected publics, and give concerned parties ample opportunity to voice their concerns and state what other alternatives should be considered.

Ideally, the Environmental Impact Assessment process will be guided by a scoping committee consisting of persons who represent authorities with some jurisdiction or special expertise; this committee should be convened whenever there is some change to the proposed action, or whenever some major obstacle to its acceptability is discovered. The principal function of this committee is to provide a forum for continuous, interactive assessment of the environmental acceptability of various aspects of the proposal as new information is obtained that may change the nature of the proposal or its impacts, and as major decision points are reached. This committee can play a vitally important role in improving the proposal by developing cost-effective compromise and mitigation measures that actually become an integral part of the proposal before the environmental report is completed.

A Class 1 Environmental Impact Assessment is concerned with accomplishing a number of specific tasks. A Class 1 assessment obviously will require more time and effort than the other two classes.[4] In order to conduct a thorough environmental assessment of major proposals, it is necessary to

- develop an understanding of the specific actions associated with the proposed action and alternative actions,
- become familiar with the nature and sensitivity of environmental elements that could be affected,
- identify all potential linkages between these actions and the affected environment, and
- identify the groups who might be differently affected by these actions.

This makes it possible to forecast and clearly define the potentially significant impacts, both beneficial and adverse, that might be expected to result from implementing the proposed action. Once they have been identified and defined, specific investigations are then required to elucidate the nature and extent of these impacts.

The general tasks of Environmental Impact Assessment are to describe:

- the purpose and need of the proposed action;
- the affected environment;
- alternatives to the proposed action;
- specific activities that would be involved for each of the actions under consideration;
- the social groups that would be differently affected by the actions under consideration;
- the possible impacts (both beneficial and adverse) of the actions under consideration; and
- ways to mitigate adverse impacts and enhance beneficial impacts.

In addition to information pertaining to these topics, the environmental impact report is expected to present background information needed to interpret and judge the quality of the assessment, such as the history of the proposed action, the identity of the proponent(s) and the decision maker(s), the identity of the assessors and their consultants, a description of methods and techniques used to gather primary data, an accounting of sources of secondary data, and a list of general references.

There are a wide range of procedures, methods and techniques that can be used to accomplish the aforementioned tasks of Environmental Impact Assessment (see Appendix A). The following discussion will focus on describing the general nature of each task, indicating very briefly what is to be accomplished, and why.

Description of Purpose and Need

A clear explanation of why the proposed action is needed, and what it is intended to accomplish, is necessary for two reasons:

- to educate parties who might oppose the action, and so achieve greater understanding (and perhaps acceptance); and
- to make it possible to identify rational alternatives to the action.

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4 Essentially the same tasks are addressed in Class 2 and 3 Environmental Impact Assessments, but in much less detail.

Description of Affected Environment

All aspects of the environment which could be affected by any of the actions under consideration are to be described in sufficient detail to convey an accurate impression of the area that will be affected and the vulnerability of the environment. The discussion is to cover both the biophysical and socioeconomic environments; this would include (but obviously not be limited to) such aspects as the following:

- geographical location and principal features
- climate
- topography and soils
- vegetation and wildlife
- population
- history
- economy
- transportation patterns
- forms of government and identity of administrating authorities
- land ownership
- land-use plans.

Description of Alternatives

In the case of public sector proposals, or private sector proposals involving public lands, all reasonable alternatives for accomplishing the stated purpose and need for the action are to be identified and assessed in the same manner as the proposed action.[5] If any major alternatives are rejected before being subjected to a detailed assessment (because, for example, they failed to meet some essential criterion or were withdrawn by proponents in favour of some other alternative), then the reasons for rejection should be given.

Description of Activities Associated with Alternative Actions

Each alternative action is to be described in sufficient detail to permit an adequate understanding of the nature and extent of those activities which could give rise to adverse environmental impacts. A new airport near a built-up area could involve, for example, building perimeter fencing, erecting lighting stanchions, excavating surrounding terrain, establishing borrow sites, erecting communication antennas, and building access roads.

Description of Affected Groups

The different interest groups or potentially concerned parties that could be differently affected by any of the proposed actions are to be identified, geographically located and described. For each social group, specific interests or potential concerns related to the actions under consideration are to be defined to the satisfaction of spokesmen for (or representative members of) the groups concerned.

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5 Private sector proponents should always be encouraged to consider viable alternatives for meeting the purpose and need of a proposal in a more environmentally-sensitive way, and give reasons for rejecting these if they are not to be formally assessed. Public sector proponents should always consider at least one major alternative: the one that is thought to be least harmful to the environment.

Description of the Potential Impacts

The principal task of Environmental Impact Assessment is to forecast and describe, as fully as possible, the impacts that could result from each of the actions under consideration. Examples of the kinds of impacts that should be considered include impacts to:

- air quality
- water quality
- solid waste
- noise
- biotic communities
- rare and endangered species
- rivers and estuaries
- wetlands
- floodplains
- coastal zone features
- historic and cultural resources
- mineral resources
- farmlands
- protected areas
- compatible land use
- community cohesion
- employment and economic activities
- emergency services.

Impacts are to be defined in such a way that it is clear how society or various social groups will be affected - the ultimate or "end" impact on social well-being (Abelson, 1976:244). The discussion of potential impacts is to include such considerations as the following:

- whether the impact is regarded as positive or negative;
- the precise nature of the impact;
- the possible magnitude of the impact (or range of possible magnitudes) and probability of occurrence (or range of probabilities associated with different magnitudes);
- the identify of affected parties, and the manner and extent to which they would be affected;
- the timing and duration of the impact;
- whether the impact could give rise to higher-order impacts;
- whether the impact could give rise to particularly significant risks;

- whether the impact is especially controversial;
- whether the impact is irreversible;
- whether the impact can be fully or partially mitigated.

Description of Possible Mitigation Measures

The Environmental Impact Assessment report is also expected to present suggestions as to how certain of the adverse impacts could be mitigated (and how some of the beneficial impacts could be enhanced), in the event that the decision maker wishes to impose any conditions on the proponent, or require an environmental management plan which specifies how the action is to be accomplished in an environmentally-sensitive manner. Under the general rubric of mitigation one can also discuss forms of compensation (either monetary or nonmonetary in nature) to individuals or groups that would bear an inordinate share of the impacts associated with the action. As mentioned above, Environmental Impact Assessment is an iterative and interactive process, the principal object of which is to discover a form of the proposed action (or that of some viable alternative) that is generally acceptable and still achieves the original purpose and need of the proposal. This will usually entail some kind of compulsory mitigation.

The Impact Report

Finally, when a draft report of the Environmental Impact Assessment is completed, an independent, impartial person or group should normally be asked to assess the report for adequacy and completeness. In addition, the draft report is to be given wide circulation for comment in order to ensure that all concerns have been heard, understood and addressed. The draft report is then amended in light of these comments before the final report goes to the decision maker.

If agreement has been reached between all concerned parties as to what should be done, then the report will constitute a record of how the preferred action was identified. If no agreement can be obtained as to what constitutes an acceptable proposal, then the report provides the decision maker (and other interested parties) with a thorough analysis of the proposed action and its principal alternatives, and the views of principal affected groups, so that a rational and more objective decision can be taken. A major object of the Environmental Impact Assessment report is to indicate which action is most acceptable in environmental terms, and to provide sufficient information to enable the decision maker to weigh environmental considerations against other factors and make a judgment as to which action is in the best overall interests of society.

APPENDIX I

THE DECISION WHETHER TO OPTIMIZE OR SATISFICE

Evaluations of major resource allocation proposals generally involve analyses that are both quantitative and qualitative. In recent years, resource economics has been shifting from an emphasis on quantitative analysis to a much more qualitative institutional analysis (Simon, 1978:6). Traditional economics was based on a particular form of rationality that was directed at maximizing goals; this required a highly quantitative analysis of resource allocation options. But today, much economic analysis could be described as functional analysis, since the object is not necessarily to discover the optimal solution, but rather to discover options which are functional because they contribute to certain goals. This means that analyses can be done without elaborate mathematical apparatus or marginal calculation; instead, much cruder and simpler arguments will often suffice to make judgments about preferences and apply evaluation criteria (Simon, 1978).

The object of resource allocation activity is to bring about an improvement in social well-being, and the object of evaluation is to reach a decision that will result in improvement for a reasonable level of effort. Satisficing rests on a very simple form of causal analysis: practices or structures are judged to entail certain undesirable or desirable outcomes, and preferences are based on these judgments. The object of a functional analysis is to increase understanding of the potential consequences so these broad judgments can be improved. When parameters are unmeasurable or especially complex, this is a rational approach. The acceptance of qualitative analysis also makes it possible to address normative questions.

Janis and Mann (1977) have stated that satisficing differs from optimizing in four ways:

- fewer criteria or decision rules are applied;
- there is a shorter search for alternatives, and fewer alternatives are generated;
- there is less concern with ordering alternatives for testing and re-testing;
- thresholds of acceptability are applied without weighting each criterion.

The idea of satisficing, then, is to reduce time and expense in evaluation and decision making, and to lessen dependency on quantitative data and focus on procedures for handling complex qualitative data. But there is a continuum between satisficing and optimizing along these four variables, and it is possible to use mixed strategies (Janis and Mann, 1977). For example, the concept of "incrementalism" or "muddling through" refers to making progress toward optimization through a series of satisficing decisions, the process which politicians often use to resolve conflict by slowly and cautiously settling problems (Bjorkman, 1987:31). "Mixed scanning" refers to a synthesis of optimizing on major aspects and satisficing on minor aspects of a decision or series of decisions, so that subservient decision problems receive less formal treatment. Another approach is called "quasi-satisficing", which involves using a single over-riding decision rule (such as efficiency) which is thought to always result in a superior solution, but this can lead to error since minimal gains in one criterion may be more than offset by losses in another.

Both satisficing and optimizing are obviously concerned with improving resource allocation decisions, but whereas optimizing is concerned with maximizing behaviour, satisficing is concerned with finding solutions that only approximate the optimum. These objectives may seem similar, but the difference is crucial in dictating the approach to evaluation that should be used. The big question is: When is it appropriate to try to optimize, and when should one simply satisfice?

The usual answer to this question is that the choice depends on the perceived importance of the problem, and the nature, extent, availability and cost of information: if the data that are needed to make an important resource allocation decision can be expressed in quantitative terms, and can be obtained and processed at a reasonable cost, then one should optimize; otherwise, one should simply satisfice (Coombs *et al.*, 1970; Janis and Mann, 1977; Simon, 1978). The satisficing model makes sense only in those situations where the process of searching for a full range of viable alternatives and evaluating the outcomes is either unfeasible or too costly - otherwise, why should one stop the search on finding a satisfactory alternative instead of looking for a better one (Coombs *et al.*, 1970:143)? But in reality, data limitations and cost constraints often do, in fact, preclude further search; in addition, processing considerations suggest that as the information load increases, people tend to replace a maximization criterion, requiring an exhaustive examination of alternatives, by a criterion that is easier to apply, such as satisficing (Coombs *et al.*, 1970:163).

For example, Decision Analysis and related methods (see Appendix D) are based on the premise that distinct and well-defined outcomes pertaining to probabilities and utilities can be formulated in the evaluation of choices. But this is often not the case when the situation is profoundly complex (Fischhoff *et al.*, 1982), and great complexity is typical of major resource allocation proposals. Bjorkman (1987:29) says that ill-defined problems, cognitive limitations and nondistinct outcomes - which characterize many pollution and resource destruction problems - make the subjective estimated utility model and its relatives fairly useless as a norm for practical decisions. The same might be said of any formal method of evaluation which involves an attempt to simplify the complexity of the real world and to quantify qualitative data which are usually regarded as unmeasurable. Perhaps the classical conception of rationality is completely unrealistic and should be replaced by a less demanding form which recognizes the limits of one's ability to obtain and process information (Coombs *et al.*, 1970).

Yet one could argue that quantitative methods are still important in highly complex problems and when qualitative data are to play a preponderant role, because the quantitative approach forces one to undertake a systematic and explicit analysis, and treat whatever data are available in a more rigorous and objective manner (Ribe, 1982:69). This suggests that it is sometimes desirable to employ quantitative methods in an <u>attempt</u> to optimize, even in the absence of clearly-defined problems and outcomes, and when there is no objective way to measure the salient data, and even when few resources are available for conducting an analysis.

In fact, one can never really optimize anyway, but only attempt to optimize. So the choice is actually between satisficing and <u>attempting</u> to optimize; but there is still an important difference between these two objectives which dictates very different approaches to the development of appropriate evaluation procedures. Satisficing is based on political rationality and employs informal methods of evaluation to inform negotiation and produce compromises which will constitute an acceptable solution to the problem; optimizing is based on economic rationality and employs formal methods of evaluation designed to objectively identify - as far as is possible - a solution that is close to optimum (see Political Rationality vs. Economic Rationality in Chapter 3).

All possible solutions to any resource allocation problem may be thought of as existing along a continuum from most satisfactory ("optimum") to least satisfactory. The methodological problem is to determine how much effort and expense should be spent on finding a <u>more</u> satisfactory (or even the optimum) solution. While the answer depends partly on how important the decision is perceived to be, how much information is believed to exist, and what the cost of this information is likely to be, it is suggested that an overriding consideration is whether the choice is expected to be highly controversial. If great controversy is anticipated, then there should <u>always</u> be an attempt to optimize; if not, then it is permissible (if other considerations dictate) to satisfice.

To sum up, it is recommended that resource managers, especially in developing countries, should adopt the satisficing rationale for evaluating resource allocation proposals, with one exception: when the anticipation of great controversy dictates an optimizing approach. In addition, an environmental evaluation methodology should provide not only for the easier (satisficing) criterion, but should also provide a simpler and less costly way to apply the optimizing criterion than that which is currently provided by Decision Analysis and other methods based on subjective expected utility.

The environmental evaluation methodology presented in this dissertation is based on a conceptual scheme which takes cognizance of both maximizing and satisficing principles, and provides for two very different approaches to evaluation and decision making, depending on the level of controversy and (by implication) significance associated with the resource allocation problem. Accordingly, if there is no significant amount of controversy surrounding a proposal, then informal evaluation procedures are normally to be utilized; alternatively, if there is (or is expected to be) great controversy, then formal evaluations are always to be conducted, using whatever resources that are available and seem reasonable to expend. The rationale is that controversial resource allocation proposals should be subjected to some attempt to optimize, even though data and procedures may not meet an ideal set of conditions, in order to reduce conflict and pave the way for acceptance of the decision.

APPENDIX J

THE ARGUMENT FOR ADOPTING A GROUP EVALUATION PROCEDURE

One of the first questions that must be addressed in developing a formal evaluation procedure is: who should do the evaluating? Possible answers include:

- Those with decision making authority.
- Assessors employed by those with decision making authority.
- All persons who would be affected by a proposed action.
- Representatives of the major groups of persons who would be differently affected by a proposed action.
- A group of neutral persons whose judgments would be respected by all concerned parties.

Ideally, all of these groups would be involved, to a greater or lesser extent, in the evaluation process. The practical problem is to establish the respective roles of these various groups, and utilize their input in a way that is mutually acceptable and involves a level of effort and expense that seems appropriate to the situation. For major, contentious issues, as a general rule, it would be desirable to always employ a group of neutral persons, survey all (or a sample of) affected parties or their representatives, and give their combined input to those with decision making authority. But what often happens is that decision makers act alone, or with the advise of their employed analysts and advisors, and the others are either left out or consulted in a haphazard way or involved after polarization has developed (and even then in a confrontational manner).

Advantages of Impartial Group Evaluations

A formal evaluation technique for judging the relative significance of impacts can, as mentioned earlier, be applied by the decision maker himself or by a committee of persons who share decision making responsibility, but because such persons occupy a special position in society they may have too narrow a perspective and may not share (or be sufficiently familiar with) the value systems of their constituencies. In addition, they will usually lack specialized knowledge and expertise in fields that are relevant to some of the issues and trade-offs to be evaluated. Finally, there is evidence that individuals are often inconsistent in their preference orderings and other judgments (Kahneman and Tversky, 1984; Tversky, 1969 and 1977; Tversky and Kahneman, 1981), and that people sometimes even choose to believe something that is not true even though they are judged to be informed and rational individuals (Akerlof and Dickens, 1982).

Other problems associated with individual evaluations include motivational limitations (such as misperception of patterns and selective attention due to wishful thinking), and selective problem formulation and selective use of data (Miller, 1985). Individual judgments are subject to a large number of biases (Spangler, 1980), and a group evaluation procedure may therefore be judged more trustworthy than procedures based on individual evaluations, particularly if there is some feedback mechanism to dampen cognitive dissonance.

A group evaluation procedure could be applied by representatives of the groups which will be affected by the decision, but then it is difficult to obtain a fair and impartial evaluation. Although direct public participation is greatly to be desired in the exploration of environmental resource allocation issues, most individuals who would be sufficiently motivated to participate will probably have some personal interest in the outcome and therefore be biased to some extent in respect of the alternatives to be evaluated. Individuals with interests at stake will tend to consciously or unconsciously manipulate the evaluation procedure to their advantage. In addition, there are practical limits on the extent to which affected publics are willing to be involved (due to other demands on their time) or can be involved (due to the lack of financial resources to conduct broad scale evaluations), particularly in the complex but all-important task of evaluating the social significance of environmental changes.

To accomplish this crucial task, which requires an open mind and a certain amount of detachment, as well as careful study and deliberation to attain an intimate familiarity with the issues and make judgments with some confidence, it is preferable to seek out respected persons representative of all points of view in society at large but who have no personal or vested interest in the outcome, and invite these individuals to serve on an evaluation panel. It is maintained that better value judgments may be obtained from panels comprised of individuals with diverse and specialized experience, and who possess relevant knowledge, or have demonstrated some special ability or earned the respect of society, provided that the individual members are unbiased with respect to the proposals at hand. It is therefore recommended that the scaling technique and some of the other tasks of the formal evaluation method should be applied by a group of individuals who represent a number of disciplines, have different backgrounds, and are perceived to be impartial in respect of the outcome.

The Potential Accuracy of Group Evaluations

Since all persons have somewhat different value systems and can be expected to differ in their value judgments, and since it is not possible to say that one person's value judgments are correct while the value judgments of all other persons are incorrect, it seems reasonable to employ some method of aggregating individual value judgments to arrive at an acceptable measure of social value. There is considerable evidence that combining the judgments of individuals can produce a more accurate estimate than can be expected of any single individual, and is almost always more accurate than the average estimate, and is sometimes better than the estimate of the best judge. Armstrong (1985:135) cites an early example of research into this interesting phenomenon:

> Gordon (1924) had college students rank weights that they lifted; these rankings were then compared to the true order, and the average correlation for 200 judges was found to be .41. By averaging the rankings of any five random judges at a time, she obtained 40 combined rankings; the average correlation between the true ranking and the combined ranking was .68. Combined estimates were also obtained from groups of 10, 20, and 50 judges, and the correlations rose to .94 for the largest group. Similar results were obtained for judgments of such things as the temperature of a room, the number of items in a bottle, and the number of buckshot.

Hill (1982) has undertaken an extensive review of group versus individual performance in matters of judgment and found that group performance is generally qualitatively and quantitatively superior to the average individual, but often inferior to the potential suggested in a statistical pooling model. This suggests that it is important to find ways to tap the potential of a group by examining the variables that affect group process. Hill therefore advocates that the group should always be comprised of high-ability members, and that procedures should be adopted which contribute to process gain through capacity to learn and cognitive stimulation.

Although it is not possible to demonstrate the accuracy of group evaluations of data which cannot be verified through objective measurement, or to measure the "correctness" of value judgments (Dalkey *et al.*, 1972:55), perhaps it is reasonable to believe that if the truth cannot be objectively determined, and if individuals disagree as to where the truth lies, then some kind of group view is a potentially more accurate determinant of truth and a more trustworthy guide to action.

The Requirements of a Group Evaluation Procedure

A major consideration in developing a group evaluation procedure is to achieve a satisfactory assessment of social value at a reasonable cost. A cost-effective evaluation procedure must be practical, adaptable, and easy to understand and apply. It must also provide acceptable results, and do this consistently, and there should be general consensus as to the usefulness and validity of the procedure. A major test of the utility of any formal procedure is simply whether practitioners and reviewers believe it works; *i.e.*, provides a reasonable and useful result. Such a belief, in turn, depends largely on two things: whether the procedure appeals to common sense, and whether it is capable of producing replicable results.

It may seem highly unlikely that evaluations conducted by two heterogeneous groups could result in judgments that are highly correlated. Every individual has a set of attitudes, beliefs, opinions, and personal goals that differs from that of every other individual, and so every individual can be said to have a unique value system. Therefore, while there may be considerable agreement amongst individuals as to whether specific impacts from some proposed action will have a positive value or a negative value, it is not surprising that there can be considerable disagreement as to the relative significance of these impacts. There are also understandable differences in the way in which different individuals would weight the three evaluation criteria of efficiency, equity and sustainability (see Defining Evaluation Criteria in Chapter 4).

The reason that individual value systems differ is that each individual has had limited and different experiences in life and has a unique genetic make-up, both of which influence his interpretation of these experiences (Wilson, 1978). Because of this, everyone has incomplete knowledge of the human condition and life's potentialities, and it is not reasonable to assume that anyone has sufficient knowledge and experience to have developed a value system which is superior to all others; even assuming the existence of such a value system, there is no objective way to recognize or identify it.

Nevertheless, most people would agree that some individuals demonstrate better judgment and possess greater wisdom than others, and it seems reasonable to assume the existence of a universal set of human values which all individuals would recognize if they could share their accumulated knowledge and experience (Dalkey *et al.*, 1972). In addition, although each individual is naturally inclined to put his own, immediate interests (or the interests of his group) before the broader, long-term public interest, most people can distinguish the difference, and it is possible to focus attention on what would be in the best interests of society as a whole by using some conceptual artifice like the Rawlesian "veil of ignorance" (Daly, 1987:329; Kneese and Schulze, 1985:203; Page, 1977:203).

It may be concluded therefore that the principal requirements of a group evaluation procedure are as follows:

- The group should be interdisciplinary and heterogeneous in composition.
- The group should be comprised of respected persons who are considered knowledgeable about the human condition and impartial as to the outcome of the evaluation.
- The cost of conducting the procedure (in terms of time, money and manpower) should be as low as possible.
- The procedure should be satisfying to participants and acceptable to decision makers and other interested parties.
- The procedure should include mechanisms for enhancing group process and minimizing bias and cognitive dissonance.
- The capability of the procedure to produce replicable results should be demonstrated.

APPENDIX K

SUMMARY OF GROENRIVIER ANALYSIS

The major tasks of the Groenrivier study were as follows:

- identify the major alternatives to be evaluated;
- identify the principal groups that would be differently affected by each alternative;
- identify the impacts associated with each alternative;
- judge the relative significance of each impact; and
- determine the relative social value of each alternative.

The project coordinator identified the alternatives, the groups that would be affected, and the impacts that would result from each alternative. An evaluation panel then judged the significance of the impacts. The panel first ranked the impacts on each list in order of importance, and then judged the relative importance of the impacts on each list. After this, the panel's judgments were used by the project coordinator to assess the efficiency of each option, and to identify the option which appeared to have the highest net social value (considering both efficiency and equity criteria). The following sections illustrate how these analyses were conducted.

Efficiency Analysis

Three pairs of mutually exclusive land-use options were considered by the panel. These will be discussed in turn.

Beach/surf Mining and Stock Farming vs National Park

The net monetary benefit of the beach/surf mining proposal (see Appendix LL) and stock farming proposal (see Appendix MM) was added to the net monetary cost of the national park proposal (see Appendix NN) to provide a contingency price against which the nonmonetizable costs of beach/surf mining and stock farming (including foregone opportunities associated with the national park) could be compared. At a 10% discount rate, the excess monetary benefit of mining and farming totalled R22,348,000; the question is whether the value of 15 nonmonetizable costs exceeds the value of this monetary benefit (see Appendix OO). This question is difficult to answer because of the indiscriminate lumping of 15 dissimilar outputs for comparison with a single sum of money. But with the panel's assessment of the relative value of these costs, each could be compared against a given proportion of the excess monetary benefit associated with the mining and farming option.

For example, the most significant nonmonetizable cost of exercising the mining and farming option, according to the panel's judgment, would be losses to the area's pristine or wilderness quality. Since this cost was determined to constitute 12,9% of the total value of all nonmonetizable costs associated with this option, a contingency price of R2,883,000 could be calculated for this cost. The decision maker can then deal with a much simpler question: would reductions in the pristine or wilderness quality of this coastline be offset by the gain of R2,883,000? If the decision maker answers "Yes", and he is prepared to accept the panel's estimate of the relative significance of the costs, then the mining and farming option is more efficient than the national park option.

The project coordinator argued that this was not the case, and suggested that the value of maintaining the pristine or wilderness quality of this area, which is perhaps the only significant stretch of the western coastline that is still relatively untouched, is worth R2,883,000 over such a long time period (50 years) to the South African people. If this is accepted, one must then consider any nonmonetizable costs associated with the park. There are two: (1) local farmers and their families would be displaced,and (2) visitors would no longer be able to exploit certain resources in the area. Since the future viability of farming in this area is in serious doubt, and since unchecked exploitation could soon deplete available resources, consideration of these costs would not alter the above conclusion.

It may be that the decision maker would wish to evaluate the contingency price(s) of some cost(s) other than the one judged most significant by the panel. For example, if the decision maker chose to assess the cost of losing the opportunity to provide hiking trails and other recreational benefits, he would compare this cost to a contingency price of R1,475,000 (6,6% of R22,348,000). Since it is difficult to assess the value of a stream of recreational benefits extending 50 years into the future, and since the future value of these benefits can be expected to increase relative to mining benefits, the decision maker can consider what the initial year's recreational benefit would have to be so that the present value of the stream of benefits would equal R1,475,000 (see Dynamic Opportunity Cost Valuation in Chapter 3).

For example, if it is thought that the price of recreational benefits will increase 5% per annum, and the quantity demanded at the given price will increase 10% per annum, then the present value of one Rand's worth of initial year's recreational benefits, discounted at 10%, is R116.60 (see Appendix BB). This means that the value of the initial year's recreational benefit required to equal the contingency price is approximately R12,700. If the value of a visitor day is estimated to be R50 (Ulph and Reynolds, 1980:120) then the number of visitors required to equal the contingency price is 254. Even allowing for the necessity of considering the nonmonetizable costs of displacing farmers and restricting exploitation of coastal resources, the project coordinator felt that it was reasonable to conclude that the park would generate enough recreational benefits to make this option more efficient than that of mining and stock farming.

General Recreation and Stock Farming vs National Park

The net monetary benefit of general recreation and stock farming, using a 10% discount rate over a 20-year time horizon, was calculated to be R165,000. (This estimate is based on shadow prices obtained for recreational benefits in the area.) This assumes that present levels of recreational use, willingness to pay, and maintenance costs will hold for the next 20 years, and stock farming will continue at a roughly break-even level.

The cost of establishing and operating a national park over this 20-year period, using a 10% discount rate, was estimated to be R4,993,000. This assumes the cost of acquiring land will be R1,700,000 and the new park will have a pattern of growth in expenditures similar to that experienced as Tsitsikamma Park over the past two decades (adjusted for inflation).

If the net monetary benefit of general recreation is added to the monetary cost of providing a national park, a contingency price is obtained for the foregone benefits of the park). This figure is R5,149,000. The most significant of the nonmonetizable costs in the panel's judgment was the foregone opportunities for hiking and other recreational benefits for the national population (see Appendix OO), which was determined to constitute approximately 22% of the value of all nonmonetizable costs associated with maintaining the status quo. If the decision maker accepts the panel's judgment as to the relative significance of these costs, then attention can be centered on this question: Would the foregone opportunities to enjoy a system of hiking trails and other recreational benefits associated with a national park and marine reserve be offset by a gain of R1,133,000? If the answer is "Yes", then the general recreation and stock farming option is more efficient than the national park option.

The project coordinator argued, however, that it seems reasonable to conclude that enough members of the South African population would receive sufficient benefits from a system of hiking trails and other park-related recreation opportunities over this 20-year period to compensate society for the loss of R1,133,000 plus bearing the nonmonetizable costs associated with the park. These costs are as follows:

- about 20 farmers and their families would be displaced - but this is a marginal farming area and local farmers may soon be forced to move anyway;
- visitors would no longer be allowed to exploit natural resources - but if exploitation is not checked resources may soon be exhausted;
- the descendants of local recreationists will be deprived of the semi-exclusive use of this traditional holiday area - but it is likely that more outsiders will begin frequenting the area and they might then prefer a national park convenient to their homes; and
- people who prefer "undeveloped" holiday areas will lose another relatively unspoiled area - but it is no longer possible to cater for any significant number of these people.

It could be argued that since general recreational use does not foreclose any options, it would be more efficient to defer proclamation of a park until demand was stronger for park benefits. However, there is a significant possibility that development pressures could arise which would lead to a transformation of the area, rendering it less suitable for park status. Because the demand for parks can be expected to increase relative to general recreational use, establishment of a national park is almost certain to be the more efficient land-use option in the long term.

Beach/surf Mining vs General Recreation

The net monetary benefit of beach/surf mining using a 10% discount rate over a 20-year time horizon was calculated to be R15,148,000. Since the net benefit of general recreation was calculated to be R156,000, the excess monetary value of beach/surf mining is R14,992,000. The panel assessed the relative value of 12 nonmonetizable costs associated with beach/surf mining (see Appendix OO), and determined that 16% of their total value was attributable to the loss of natural beauty in the area due to physical alterations in the landscape by mining activities. The contingency price for this cost is therefore R2,399,000. If one accepts the panel's assessment as to the relative significance of this cost, the central question is whether society could be compensated for this loss of natural beauty by receiving R2,399,000. If the decision maker feels this amount of money would be adequate compensation, then the mining option is more efficient.

But the project coordinator argued that it seems reasonable to assume that as recreational resources become congested in other parts of the western Cape, the recreation catchment of the Groenrivier area will grow substantially and that even today potential users of the resource would require more compensation than R2,399,000 for accepting the loss of natural beauty along this 75 km stretch of coastline.[6] If this is true, then one must consider the nonmonetizable costs of the alternative, using the area for general recreation. Choosing this option over the mining option would mean foregoing opportunities for creating employment related to mining operations (an estimated 100 jobs) and stimulating the local economy (particularly in the Garies region). However, these are not likely to be significant since few unemployed resources would be used (many of the jobs are skilled or semi-skilled and would simply involve a transfer of resources from one sector to another), and since little additional trade would be created in the local area. It might be concluded therefore that the nonmonetizable costs of mining outweigh its large excess monetary value, and that the alternative - general recreational use - is more efficient even though the net monetary benefit is very small.

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6 The reasoning here is that although non-locals would prefer the national park to general recreation, and that present regional willingness to pay for general recreation would be nil, if the choice is between beach/surf mining and general recreation, then future willingness to pay for general recreation will be adequate to meet the calculated fractional contingency price.

Conclusion

An analysis of contingency prices for the options with excess monetary value indicates that the value of the nonmonetizable costs associated with these options outweighs the value of their benefits. Following is a summary of the results:

- A national park would be more efficient than beach/surf mining.
- A national park would be more efficient than general recreational use.
- General recreation use is likely to be more efficient than beach/surf mining.

The project coordinator concluded that the most efficient land-use option would be the establishment of a national park and marine reserve.

Analysis of Distributional Consequences and Evaluation of the Efficiency-Equity Trade-off

A development which is judged to be socially efficient may not be socially desirable if it results in an inequitable distribution of costs and benefits. Decision makers need to weigh the net benefit of an option against the distributional consequences of that option. If an action is only marginally efficient but grossly inequitable, it may be judged socially undesirable. Therefore after the efficiency analysis was done, the project coordinator analysed the distributional effects of the alternatives in order to arrive at a final determination as to which one had the highest net social value. The following discussion is based on the project coordinator's analysis of the distributional consequences of the three land-use options as presented in Box 4.1 of Chapter 4.

The national park option offers benefits to far more people than the other two options, but imposes costs on a few small groups. Costs to shareholders and employees of De Beers may not be considered very significant since other investment and job opportunities are available elsewhere, and this group would not actually be giving up something which has been a source of satisfaction. Costs to casual visitors are also relatively inconsequential since such visitors appear to be few in number and most of these individuals would probably prefer visiting a national park than visiting an increasingly crowded general recreation area. The most significant costs would be borne by the 20 farmers and the 300 local residents who visit the area regularly.

The farmers would bear the heaviest costs since they would be required to leave their homes and may be forced to move out of the area and find new farms or occupations. Monetary payments may not be adequate to compensate these people for suffering these costs. However, one must take into consideration the fact that only 20 families are affected, and since this area is not very suitable for farming, these families may soon face economic dislocation in any case. (In addition, most of the farmers are tenants of De Beers, which could withdraw the land at six months' notice to start new mining operations.)

Some of the 300 local residents who presently use the area would also suffer significant costs because they would not consider national-park facilities to be an acceptable substitute for their traditional holiday site. (It is perhaps questionable whether their descendants would prefer the undeveloped site to a national park, but this may indeed by the case.) Some of these people might be able to find alternative holiday sites which are suitable, but others would probably have to stay home or have less satisfactory holidays.

The large and diverse group which would benefit from the establishment of a national park do have alternative areas for satisfying their interests, but as their number grows these will become increasingly inadequate. It may be argued that to deprive such a great number of people of the many conservation and recreation benefits this area could provide is, in the long run, even more inequitable than the costs which would be imposed on much smaller groups by proclaiming a national park.

In conclusion, general recreational use appears to be a more equitable land-use option than beach/surf mining because it would provide for the holiday wants of local residents, and the significance of the area to this group would seem to outweigh its significance to the well-being of De Beers shareholders and prospective employees. However, the establishment of a national park could eventually (or even now) be of greater importance to a much larger number of people than the 300+ who would benefit from general recreational use. Therefore, the most equitable land-use (at least in the long term) would appear to be the one which is also most efficient, *viz.* a national park and marine reserve.

If this assessment of the distributional consequences of the three land-use options is accepted, then there is no ambiguity as to how the options should be ranked, since the same ordering was obtained for the efficiency criterion. The options can now be ranked according to their net social value:

1. National park and marine reserve.

2. General recreation and stock farming.

3. Beach/surf mining and stock farming.

In light of this conclusion, the project coordinator recommended adoption of the national park and marine reserve.

APPENDIX L

RESULTS OF THE CONTINGENT VALUATION SURVEY AND THE KRUTILLA ANALYSIS IN CASE STUDY 4

Introduction

The Contingent Valuation Survey technique (U.S. Water Resources Council, 1980) is one of the shadow-pricing techniques based on the willingness to pay concept (see Shadow-pricing Techniques in Chapter 3). This technique provides estimates of values for goods by using simulated markets. This permits the calculation of prices for unpriced values and thus clarifies the true trade-offs that are involved. The technique consists of asking individuals who are representative of the affected population a series of questions to determine their maximum willingness to pay for a given quantity of the nonmarketable good (in this case, the special values associated with preserving varying amounts of the Kogelberg State Forest).

Another useful evaluation technique is that developed by Krutilla *et al.* (1972). This technique projects shifts in the relative value of specific costs and benefits over time (see Dynamic Opportunity Cost Valuation in Chapter 3). Since some benefits may be expected to depreciate over time while other benefits may appreciate over time, it is necessary to forecast changes in relative value over some period which seems appropriate if these changes are judged likely to be significant. This procedure involves making projections of scarcity value based on different assumptions about changes in such variables as technological advance, availability of substitutes, population growth, real income, mobility, and leisure time.

The Contingent Valuation Survey

A central question which the Directorate of Water Affairs wanted answered was whether water consumers would be willing to pay higher costs for water in order to avoid or limit damage to the Kogelberg State Forest. It was decided to use the Contingent Valuation Survey technique to ask a representative sample of water consumers how much extra they would be willing to pay on their water bill every month to permit the Weir to be built in preference to the Dam, or to permit a Desalination works to be built in preference to the Weir. Since the Directorate of Water Affairs had indicated that its policy was to make the users of a water facility pay for the full costs of its provision, emphasis was placed on conducting a local survey. Nevertheless, since the Kogelberg State Forest was widely regarded as a national asset, and since the early implementation of desalination technology could be regarded as in the national interest, it was thought appropriate to provide the Directorate with information pertaining to the willingness of water users in other parts of the country to pay for avoiding damage to part or all of the reserve, and to permit earlier development of desalination technology. Therefore, a national postal survey was also conducted.

The local survey consisted of personal interviews with white households, randomly selected from communities in the region served by the Cape Town Water Undertaking, since this was the largest user group (and the one that would have to bear the brunt of increased water rates), and since the costs of surveying other groups would be excessive. The survey instrument was designed and tested by the project coordinator, and then third-year university students from the Department of Social Studies, at the University of Cape Town conducted nearly 200 interviews in the Greater Cape Town area.

The interview procedure was to first explain, with the use of maps and visual aids, the alternatives and their implications, and then to ask the respondent (the head of the household) whether he would be willing to pay an additional R1 on his monthly water bill, along with all other water users, to subsidize the implementation of one alternative in preference to another. If the reply was "yes", then the respondent would be asked whether an additional R2 per month would be acceptable. The cost per month would continue to be raised in this fashion until the respondent indicated that the amount required had reached an unacceptable level. If the respondent was unwilling to pay any additional amount on his water bill, questions were asked to determine whether this was because he did not value the area that would be conserved, or whether this was a protest response.

For the nationwide postal survey, a standing consumer panel utilised by a private market research firm was employed. Members of the panel were paid by the firm to answer questions on a series of subjects every month. The panel consisted of 2,250 members and was considered to constitute a reliable cross-section of the adult white population of South Africa.

A thorough explanation of the alternatives and trade-offs involved could not be communicated in the postal survey, nor could the iterative bidding procedure be employed. The choice between the Dam and the Weir was regarded as too complex and so was not presented. Instead, respondents were asked to indicate the maximum amount they would pay extra on their monthly water bill to provide funding for a Desalination works so that no water storage facility would be required in the Kogelberg State Forest. The survey was conducted twice, and in the second survey an additional question was provided to identify protest responses.

The results of the local survey indicated that white households in the Cape Town metropolitan area were prepared to pay, on average, an additional R3.43 per month on their water bill to save a portion of the Kogelberg State Forest by building the Weir instead of the Dam, or an additional R4.07 per month to preserve the entire Kogelberg State Forest by financing Desalination. Since the average household consumption had been estimated to be 184 cubic metres per year, this meant that consumers were, on average, willing to pay an extra 22 cents per cubic metre for the Weir, and 27 cents per cubic metre for Desalination. Estimates of the average cost from all sources, if 104 million cubic metres of water per year were to be obtained from the Weir rather than the Dam, had been calculated to be an extra 1 cent per cubic metre (37 cents vs. 36 cents); if this amount of water were to be obtained from Desalination rather than the Dam, it would cost an extra 30 cents per cubic metre (66 cents vs. 36 cents). This meant that the local population had expressed sufficient willingness to pay for the Weir over the Dam (22 cents per cubic metre instead of only 1 cent), but insufficient willingness to pay for Desalination over the Dam (27 cents per cubic metre instead of the necessary 30 cents). Therefore, the Dam was judged to be marginally more efficient than Desalination, but the Weir substantially more efficient than the Dam.

The results of the nationwide postal survey indicated that white households across the country were prepared to pay, on average, an additional R7.29 on their monthly water bill to finance early implementation of Desalination and preserve all of the Kogelberg State Forest. Since there were an estimated 1,3 million white households in South Africa, their combined willingness to pay for a Desalination facility in the Cape that would provide 104 million cubic metres per year amounted to an estimated R113,724,000, compared to the R31,200,000 that would be required to pay the additional cost of 30 cents per cubic metre. Since the necessary willingness to pay would be only R2.00 per month, and the expressed willingness to pay was R7.29 per month, Desalination was judged to be more efficient than the Dam if water consumers in all parts of the country were allowed to subsidize the extra cost.

There were some difficulties with the Contingent Valuation Survey. Not all water users were included in the sample design (*e.g.*, industrial concerns, non-white households) because of budget limitations. Also, in an attempt to reduce costs, student interviewers were used and they proved to be somewhat unreliable. In addition, it is questionable how well the respondents understood the complex nature of the trade-offs before undertaking the bidding procedure (anticipation of this problem is one reason why a Delphi evaluation was also done), and the postal respondents had even less information and could not use a bidding procedure so that the quality of their judgments are also suspect.

Finally, there is a fundamental difficulty with the concept of asking a person's hypothetical willingness to pay for something without reference to other hypothetical demands on his budget. Such judgments about particular trade-offs, considered in isolation from other plausible trade-offs, would have a consistent bias toward overvaluation; for example if a person is asked his willingness to pay to achieve each of a number of objectives, the average figure is likely to be higher if each is considered independently rather than all simultaneously. Nevertheless, the survey gave some useful indications of public attitudes and values that would have otherwise not be obtained, and the respondents were motivated to answer truthfully because they understood that the results of the survey could influence the decision and they would actually have to bear the costs (*i.e.*, higher water bills or conservation losses).

The Krutilla Model

Since the relative importance of fynbos conservation and conventional water storage facilities could dramatically alter in the next few decades, and since the monetary costs of Desalination would be much greater than the monetary costs of the Dam, it was considered appropriate to supplement the results of the Contingent Valuation Survey with a range of estimates of the dynamic opportunity costs associated with the Dam. A computer model for calculating the possible magnitude of these dynamic opportunity costs was developed following the approach adopted by Krutilla et. al. (1972).[7]

Since the choice of discount rate and changes in variables affecting rates of technological advance and demand for conservation benefits are matters of personal judgment, a range of values was supplied so that the decision maker could select those which he feels are most appropriate. This information was presented in a series of tables so that the decision maker could easily determine the initial year's willingness to pay (from either the local or national populations) required to equalize the excess monetary value of one alternative over another under various assumptions, acceptable to him, regarding the relevant time horizon, and the annual rate of discount, technological replacement, and demand for conservation (see Table L.1).

As mentioned earlier, the Directorate of Water Affairs had indicated that its policy was to make the users of a water resource responsible for paying the full costs of providing the water. The results of the Contingent Valuation Survey would, therefore, indicate that the Weir is the more efficient alternative given present valuations of the principal trade-offs involved. But relative valuations are likely to change over time, and the Krutilla Model can be applied to determine under what set of assumptions the expressed willingness to pay for Desalination would be adequate to make it the more efficient alternative.

The analysis done using the Krutilla model indicates that the present willingness to pay for Desalination could be sufficient given that certain assumptions are accepted. Since there were an estimated 143,000 white households in the Cape metropolitan area, and their average willingness to pay had been judged to be R48.84 per year, the initial year's willingness to pay is calculated to be R6,984,000. Then if one assumes, for example, that the appropriate rate of discount is 3%, the rate of technological replacement is 4%, the growth in demand for conservation is 4%, and the relevant time horizon is 45 years, the Krutilla model indicates that the initial year's willingness to pay that is required is only R6,960,000. Given these assumptions, Desalination is the more efficient alternative even if the national willingness to pay is disregarded.

The Krutilla Model seemed to be understood and the rationale underpinning the model generally accepted by the Water Affairs officials with whom the research team had contact, but it is difficult to gauge the level of understanding and degree of acceptance on the part of the ultimate decision makers. There is great uncertainty about the costs of desalination, the appropriate rate of discount, the rate of technological advance, and the rate at which demand for fynbos conservation will increase, but an attempt was made to provide a range of values for these factors that would encompass the extremes of opinion.

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7 This model was developed by Ms. Shirley Butcher of the Department of Environmental and Geographical Science, University of Cape Town.

TABLE L.1
Output from "Krutilla Model"

45-year time horizons for both CONSERVATION and DAM

INITIAL YEAR'S BENEFIT FROM DAM = R29.4 million

	DISCOUNT RATE = 3%				DISCOUNT RATE = 6%				DISCOUNT RATE = 10%			
	R	PVP	PVD	BPI	R	PVP	PVD	BPI	R	PVP	PVD	BPI
PI=1%	1%	29.60	606.24	20.48	1%	17.90	397.10	22.18	1%	10.98	262.54	23.91
	2%	36.24	606.24	16.73	2%	20.98	397.10	18.92	2%	12.32	262.54	21.30
	3%	45.00	606.24	13.47	3%	24.90	397.10	15.95	3%	13.95	262.54	18.82
	4%	56.64	606.24	10.70	4%	29.93	397.10	13.27	4%	15.94	262.54	16.47
	5%	72.24	606.24	8.39	5%	36.46	397.10	10.89	5%	18.41	262.54	14.26
	6%	93.28	606.24	6.50	6%	45.00	397.10	8.82	6%	21.50	262.54	12.21
PI=2%	1%	29.60	518.00	17.50	1%	17.90	351.28	19.62	1%	10.98	239.63	21.82
	2%	36.24	518.00	14.29	2%	20.98	351.28	16.74	2%	12.32	239.63	19.44
	3%	45.00	518.00	11.51	3%	24.90	351.28	14.11	3%	13.95	239.63	17.18
	4%	56.64	518.00	9.15	4%	29.93	351.28	11.74	4%	15.94	239.63	15.03
	5%	72.24	518.00	7.17	5%	36.46	351.28	9.63	5%	18.41	239.63	13.02
	6%	93.28	518.00	5.55	6%	45.00	351.28	7.81	6%	21.50	239.63	11.15
PI=3%	1%	29.60	449.00	15.17	1%	17.90	314.11	17.54	1%	10.98	220.25	20.06
	2%	36.24	449.00	12.39	2%	20.98	314.11	14.97	2%	12.32	220.25	17.87
	3%	45.00	449.00	9.98	3%	24.90	314.11	12.61	3%	13.95	220.25	15.79
	4%	56.64	449.00	7.93	4%	29.93	314.11	10.49	4%	15.94	220.25	13.81
	5%	72.24	449.00	6.22	5%	36.46	314.11	8.62	5%	18.41	220.25	11.96
	6%	93.28	449.00	4.81	6%	45.00	314.11	6.98	6%	21.50	220.25	10.25
PI=4%	1%	29.60	394.23	13.32	1%	17.90	283.54	15.84	1%	10.98	203.69	18.55
	2%	36.24	394.23	10.88	2%	20.98	283.54	13.51	2%	12.32	203.69	16.53
	3%	45.00	394.23	8.76	3%	24.90	283.54	11.39	3%	13.95	203.69	14.60
	4%	56.64	394.23	6.96	4%	29.93	283.54	9.47	4%	15.94	203.69	12.77
	5%	72.24	394.23	5.46	5%	36.46	283.54	7.78	5%	18.41	203.69	11.06
	6%	93.28	394.23	4.23	6%	45.00	283.54	6.30	6%	21.50	203.69	9.48

KEY:

Initial year's benefit from dam = Excess monetary value of dam in year one, ie 98 million cubic metres at price differential of 30c per m^3

R	Growth rate in demand for conservation
PI	Rate of technological replacement
PVP	Discounted net present value per R1 spent on conservation in the initial year
PVD	Discounted present value of the benefit from the dam (million Rands)
BPI	The amount required for conservation in the initial year in order to equal the value of the development (million Rands)

APPENDIX M
Means and Standard Deviations for Impact Ratings by Nine Panels in Case Study 4

PANEL A

		DAM vs WEIR			WEIR vs DAM			DAM vs DESAL			DESAL vs DAM		
		ITERATION			ITERATION			ITERATION			ITERATION		
		1	2	3	1	2	3	1	2	3	1	2	3
	n	15	15	15	15	15	15	8	10	10	8	10	10
A	mean	3,6	3,3	2,9	2,9	2,6	2,5	4,6	4,7	4,7	5,9	5,9	6,0
	std dev	1,8	1,4	1,2	1,6	1,3	1,0	1,2	0,5	0,5	0,9	0,8	0,8
B	mean	3,9	3,7	3,5	5,5	5,8	5,9	4,4	4,4	4,2	3,1	3,6	3,3
	std dev	1,5	0,9	0,7	1,1	1,0	1,0	1,2	0,9	0,7	1,1	1,0	0,8
C	mean	3,9	3,5	3,3	6,3	6,2	6,5	3,8	3,9	3,8	4,1	4,0	3,9
	std dev	1,5	1,1	1,1	1,2	1,4	1,3	1,4	1,2	1,2	0,9	0,8	0,7
D	mean	4,3	4,2	3,9	3,1	3,1	3,1	4,3	4,3	4,2	6,4	6,5	6,6
	std dev	1,5	0,9	0,8	1,3	1,3	1,0	1,5	1,0	0,9	0,5	0,5	0,5
E	mean	2,5	2,1	2,1	4,3	4,7	4,9	3,6	3,6	3,4	4,9	5,3	5,3
	std dev	1,4	1,0	0,9	1,6	1,2	1,1	1,5	0,8	0,7	1,1	0,9	0,8
F	mean	4,6	4,3	3,8	4,1	4,3	3,9	2,1	2,2	1,7	4,4	4,3	4,4
	std dev	1,7	1,3	1,0	1,5	1,5	1,3	1,1	1,2	0,8	1,8	1,6	1,4
G	mean	3,1	3,1	2,5				2,6	2,8	2,1	5,0	5,4	5,5
	std dev	1,3	1,1	0,8				1,5	1,4	1,0	1,3	0,9	0,9
H	mean	3,7	3,7	3,7				2,8	2,8	2,4	5,9	6,0	6,0
	std dev	1,2	0,9	0,8				1,3	1,0	0,8	0,6	0,4	0,0
I	mean	2,4	2,2	2,0				2,3	2,2	2,0	5,3	5,8	5,8
	std dev	1,0	1,0	0,6				0,7	0,9	0,4	1,7	1,2	1,2
J	mean	3,7	3,9	3,6							3,6	3,8	3,6
	std dev	1,4	1,2	1,0							1,6	1,2	1,3
K	mean	4,6	4,7	4,3							3,1	2,9	2,1
	std dev	1,5	1,1	1,0							1,5	1,2	0,5
L	mean	3,8	3,7	3,2							3,8	3,6	3,7
	std dev	1,4	1,2	0,7							1,2	0,9	1,0
M	mean	3,1	3,0	2,8									
	std dev	1,1	0,8	0,5									
N	mean	3,5	3,2	2,8									
	std dev	1,5	1,3	0,9									

PANEL B

		DAM vs WEIR			WEIR vs DAM			DAM vs DESAL			DESAL vs DAM		
		ITERATION			ITERATION			ITERATION			ITERATION		
		1	2	3	1	2	3	1	2	3	1	2	3
	n	11	8	10	11	7	10	13	12	13	13	13	13
A	mean	3,5	3,8	3,6	2,3	1,6	1,6	4,1	3,8	3,9	5,8	6,2	6,2
	std dev	1,5	1,4	1,3	1,1	0,5	0,5	1,5	0,7	1,2	1,5	1,7	1,7
B	mean	3,7	4,1	3,7	5,5	5,0	5,2	4,4	3,9	3,8	2,7	2,2	2,1
	std dev	1,5	1,5	1,5	0,7	1,7	1,5	1,5	1,1	1,1	1,8	1,0	0,5
C	mean	3,2	3,4	3,4	6,6	6,0	6,2	3,5	3,0	3,0	3,9	3,5	4,2
	std dev	1,4	1,7	1,5	0,6	2,1	1,8	1,6	0,8	0,7	1,8	1,1	1,0
D	mean	4,3	4,1	3,9	2,5	2,3	2,3	4,8	4,8	4,8	6,3	6,5	6,5
	std dev	1,5	1,1	0,8	1,2	1,2	0,8	1,5	1,2	1,0	1,4	0,9	0,9
E	mean	2,4	2,1	1,8	4,5	4,4	4,5	3,9	3,8	3,6	4,8	5,1	4,8
	std dev	1,4	0,8	0,7	1,7	1,6	1,6	1,6	1,2	1,1	1,5	1,0	0,9
F	mean	5,4	5,5	5,5	4,0	4,0	3,9	2,4	2,1	2,1	4,0	4,2	3,8
	std dev	0,9	1,1	0,8	2,0	1,8	1,4	1,7	1,8	1,7	1,6	1,6	1,5
G	mean	2,6	2,5	2,4				2,8	2,3	1,9	4,9	5,3	5,4
	std dev	1,6	1,3	1,2				1,7	1,4	1,1	1,3	1,0	0,9
H	mean	3,6	3,8	3,8				2,5	2,0	1,8	4,8	5,0	5,0
	std dev	2,0	1,6	1,3				1,2	0,8	0,6	1,3	1,0	0,8
I	mean	1,6	1,9	1,5				1,4	1,2	1,2	5,2	5,3	5,5
	std dev	0,8	0,8	0,5				0,6	0,4	0,4	1,7	1,4	1,3
J	mean	3,7	4,1	4,3							3,5	3,8	3,9
	std dev	1,5	0,6	0,8							1,4	1,2	1,1
K	mean	5,4	5,4	5,4							2,5	2,3	2,4
	std dev	0,9	0,7	0,7							1,2	0,7	0,5
L	mean	2,7	2,5	2,2							4,5	4,5	4,9
	std dev	1,5	1,1	0,7							1,9	1,4	1,3
M	mean	3,4	3,5	2,9									
	std dev	1,7	1,9	1,6									
N	mean	2,4	2,0	2,0									
	std dev	1,0	0,7	0,6									

PANEL C

		DAM vs WEIR			WEIR vs DAM			DAM vs DESAL			DESAL vs DAM		
		ITERATION			ITERATION			ITERATION			ITERATION		
		1	2	3	1	2	3	1	2	3	1	2	3
	n	11	11	11	11	11	11	11	11	11	11	11	11
A	mean	4,3	4,5	3,9	2,5	2,1	2,0	4,6	5,1	4,9	5,1	5,6	5,5
	std dev	1,6	1,2	1,3	1,2	0,9	0,6	1,7	1,2	1,0	1,9	1,1	1,3
B	mean	4,6	5,2	4,9	4,0	4,3	3,9	4,5	5,0	5,1	2,5	1,9	1,7
	std dev	1,2	0,7	0,5	1,8	1,1	0,7	1,0	0,7	0,5	1,4	0,8	0,6
C	mean	4,6	4,7	5,0	5,3	5,4	5,5	4,6	5,0	4,7	3,7	4,1	4,2
	std dev	1,3	1,0	1,0	0,7	0,6	0,7	1,4	1,0	1,0	1,8	1,4	1,4
D	mean	4,3	4,5	4,7	2,9	3,5	3,5	4,7	4,9	5,0	6,0	6,2	5,9
	std dev	1,4	0,9	0,7	1,2	1,2	1,0	1,0	0,8	0,7	1,1	0,6	0,8
E	mean	2,9	2,8	2,6	4,5	4,3	4,6	4,5	4,8	4,7	4,9	4,7	5,0
	std dev	1,2	0,8	0,9	0,9	1,0	0,8	1,2	1,0	1,1	1,4	1,2	1,1
F	mean	4,6	4,9	4,6	3,9	3,6	3,9	2,9	2,6	2,5	3,6	3,6	3,5
	std dev	1,6	1,0	0,6	1,5	1,1	0,8	1,5	1,2	0,8	1,4	1,1	1,1
G	mean	3,,5	4,1	3,7				3,4	3,3	3,8	5,2	5,3	5,4
	std dev	1,6	1,0	1,2				1,7	1,4	1,0	1,7	1,1	1,1
H	mean	3,6	3,6	3,9				3,2	3,0	3,1	5,1	5,5	5,5
	std dev	1,7	1,1	0,9				1,0	0,9	0,7	1,9	1,2	0,9
I	mean	1,8	2,2	2,0				1,9	2,2	2,0	4,6	4,5	4,4
	std dev	0,7	0,8	1,0				0,9	1,0	0,9	2,2	1,7	1,2
J	mean	4,1	4,6	4,3							3,4	3,3	3,5
	std dev	1,6	1,1	0,9							1,4	1,1	1,1
K	mean	5,1	5,2	5,2							2,6	2,2	2,3
	std dev	1,1	1,0	1,0							1,2	0,6	0,6
L	mean	3,4	3,7	3,7							3,4	3,3	3,3
	std dev	1,4	1,1	0,9							1,7	1,4	0,9
M	mean	2,7	2,6	2,5									
	std dev	1,3	1,4	1,2									
N	mean	3,4	3,1	3,0									
	std dev	1,1	0;8	0,7									

PANEL D

		DAM vs WEIR			WEIR vs DAM			DAM vs DESAL			DESAL vs DAM		
		ITERATION			ITERATION			ITERATION			ITERATION		
		1	2	3	1	2	3	1	2	3	1	2	3
	n	15	13	15	15	13	15	15	13	15	15	13	15
A	mean	4,0	4,3	4,3	2,9	2,4	2,4	4,1	4,5	4,7	5,5	5,5	5,9
	std dev	1,4	1,4	1,4	1,5	1,4	1,2	1,7	1,4	1,3	1,7	1,3	1,1
B	mean	4,2	4,4	4,3	4,7	4,7	4,4	4,2	4,4	4,4	4,0	3,5	3,7
	std dev	1,5	1,4	1,4	1,1	0,7	0,6	1,4	1,3	1,0	1,5	1,1	1,0
C	mean	4,6	4,7	5,0	5,5	5,4	5,7	4,3	4,5	5,0	4,4	4,1	4,3
	std dev	1,6	1,3	1,4	1,0	1,0	0,6	1,4	1,3	1,1	1,2	1,0	0,8
D	mean	4,5	4,5	4,5	4,1	3,8	3,7	4,9	5,0	5,0	5,9	5,8	5,9
	std dev	1,1	0,8	1,0	1,4	1,3	1,4	1,1	1,0	0,8	1,2	1,2	0,9
E	mean	3,2	3,0	3,1	4,9	4,8	4,9	4,3	4,7	5,0	5,1	4,9	4,9
	std dev	1,4	1,2	0,9	1,4	1,0	1,0	1,4	1,5	1,3	1,1	0,8	0,9
F	mean	4,5	4,2	4,5	4,7	4,4	4,4	3,0	3,2	3,2	4,3	4,4	4,4
	std dev	1,5	1,3	1,1	1,7	1,3	1,3	1,3	1,2	0,9	1,5	1,4	1,4
G	mean	3,9	3,8	3,8				3,7	3,3	3,3	5,3	5,3	5,2
	std dev	1,5	1,5	1,3				1,4	1,3	1,1	1,1	0,7	0,5
H	mean	3,3	2,9	2,7				3,5	3,5	3,7	5,5	5,5	5,6
	std dev	1,4	1,1	0,8				1,6	1,4	1,2	1,3	0,9	0,8
I	mean	2,5	2,2	2,1				2,7	2,4	2,7	5,6	5,7	5,8
	std dev	1,4	0,7	0,6				1,2	0,7	0,9	1,5	1,5	1,4
J	mean	3,9	3,7	3,9							4,5	4,5	4,4
	std dev	1,1	0,9	0,7							1,7	1,7	1,5
K	mean	4,7	4,8	5,1							3,5	3,4	3,1
	std dev	1,2	0,9	0,8							1,6	1,3	1,3
L	mean	3,6	4,0	3,9							3,8	3,7	3,7
	std dev	1,5	1,4	1,3							1,2	1,0	0,6
M	mean	3,0	3,5	3,3									
	std dev	1,4	1,5	1,2									
N	mean	3,5	3,5	3,4									
	std dev	1,5	1,4	1,3									

PANEL E

		DAM vs WEIR			WEIR vs DAM			DAM vs DESAL			DESAL vs DAM		
		ITERATION			ITERATION			ITERATION			ITERATION		
		1	2	3	1	2	3	1	2	3	1	2	3
	n	19	17	17	19	17	17	19	17	17	19	17	17
A	mean	4,1	3,9	4,5	2,3	2,2	1,8	5,1	4,6	4,8	4,5	4,7	4,2
	std dev	1,6	1,5	1,2	1,3	0,9	0,6	1,3	1,4	1,3	1,5	1,2	1,1
B	mean	4,3	4,6	4,8	4,6	5,0	4,6	5,5	5,2	5,4	2,8	2,6	2,4
	std dev	1,6	1,3	1,0	1,5	1,2	1,2	1,0	1,1	1,0	1,3	1,0	0,8
C	mean	4,2	4,3	4,0	5,8	6,2	6,2	4,6	4,4	4,5	3,5	3,2	3,2
	std dev	1,7	1,4	1,3	1,2	0,9	0,9	1,6	1,4	1,3	1,2	0,7	0,9
D	mean	4,2	4,2	4,2	3,6	3,4	2,8	5,0	5,2	5,3	5,9	6,2	6,4
	std dev	1,4	0,8	0,8	1,7	1,2	1,1	1,3	1,0	1,0	1,0	0,9	0,8
E	mean	2,0	1,9	1,7	4,4	4,6	4,4	4,6	4,2	3,9	4,8	5,1	4,5
	std dev	0,9	0,7	0,6	1,5	1,1	0,9	1,3	1,4	1,1	1,4	1,1	0,9
F	mean	4,3	4,8	4,8	3,6	3,8	3,2	2,7	2,4	2,3	3,5	3,5	3,0
	std dev	1,0	1,0	0,9	1,6	1,6	1,3	1,6	1,3	1,2	1,5	1,0	0,9
G	mean	3,2	3,1	2,9				3,4	3,1	2,8	5,1	5,1	4,7
	std dev	1,3	1,0	0,8				1,5	1,4	1,2	1,2	1,3	1,0
H	mean	3,2	3,1	2,9				2,7	2,4	2,0	5,1	5,4	5,4
	std dev	1,6	1,1	1,0				1,2	1,0	0,6	1,4	0,9	0,9
I	mean	2,0	1,8	1,6				2,4	2,1	1,8	4,7	4,9	4,8
	std dev	1,3	1,3	1,0				1,5	1,3	1,0	1,8	1,5	1,5
J	mean	3,7	4,1	4,0							3,5	3,2	2,9
	std dev	1,5	1,3	1,2							1,4	1,2	0,9
K	mean	4,6	5,6	5,3							2,4	2,2	1,6
	std dev	1,8	0,9	1,4							1,5	1,1	0,6
L	mean	3,1	2,5	2,3							3,1	3,3	3,0
	std dev	1,4	0,9	0,6							1,6	1,1	1,0
M	mean	2,7	2,2	2,2									
	std dev	1,3	1,1	1,1									
N	mean	3,2	2,9	2,7									
	std dev	1,3	1,3	1,2									

PANEL F

		DAM vs WEIR			WEIR vs DAM		
		ITERATION			ITERATION		
		1	2	3	1	2	3
	n	18	18	18	18	18	18
A	mean	2,7	2,2	1,9	2,2	1,9	2,1
	std dev	1,7	1,4	1,2	1,1	0,6	0,5
B	mean	4,3	4,2	4,2	4,7	4,8	4,9
	std dev	1,6	1,0	1,0	1,,6	1,2	0,9
C	mean	4,8	5,1	5,1	6,7	6,8	6,9
	std dev	1,4	1,0	0,8	0,7	0,5	0,5
D	mean	4,2	4,2	4,0	2,8	2,1	2,0
	std dev	1,5	1,1	0,9	1,6	0,9	0,7
E	mean	2,0	1,8	1,8	5,6	6,1	6,1
	std dev	0,9	0,6	0,5	1,8	1,4	0,8
F	mean	4,3	4,1	3,4	4,2	4,5	3,9
	std dev	2,1	2,0	1,7	2,0	1,6	1,1
G	mean	2,4	2,3	2,1			
	std dev	1,5	1,3	0,9			
H	mean	2,3	2,1	2,0			
	std dev	1,4	1,1	0,9			
I	mean	2,4	2,1	2,1			
	std dev	1,1	0,8	0,5			
J	mean	3,8	3,8	3,8			
	std dev	1,7	1,2	0,9			
K	mean	5,1	5,1	5,1			
	std dev	1,6	1,4	1,3			
L	mean	3,2	2,8	2,4			
	std dev	1,7	1,4	1,0			
M	mean	3,1	2,3	1,9			
	std dev	1,6	1,3	0,7			
N	mean	3,4	2,9	2,6			
	std dev	2,0	1,6	1,1			

PANEL G

		DAM vs WEIR			WEIR vs DAM		
		ITERATION			ITERATION		
		1	2	3	1	2	3
	n	18	18	18	18	18	18
A	mean	2,7	2,2	2,2	2,6	2,2	2,2
	std dev	1,4	0,6	0,8	1,5	0,7	0,5
B	mean	3,9	4,0	3,9	4,2	4,2	4,2
	std dev	1,7	1,3	1,2	1,6	1,4	1,3
C	mean	4,0	4,1	4,2	5,9	6,1	6,2
	std dev	1,8	1,5	1,3	1,2	1,0	0,9
D	mean	3,8	3,7	3,5	2,4	2,3	2,2
	std dev	1,4	1,2	1,0	1,2	0,9	0,7
E	mean	2,6	2,2	2,2	4,9	5,1	4,9
	std dev	1,3	0,5	0,5	1,6	1,1	0,8
F	mean	4,2	4,3	4,1	3,5	3,7	3,8
	std dev	2,0	1,7	1,5	1,7	1,5	1,6
G	mean	2,7	2,6	2,3			
	std dev	1,4	1,3	1,1			
H	mean	2,7	2,4	2,2			
	std dev	1,6	1,2	0,7			
I	mean	2,7	2,1	1,9			
	std dev	1,0	0,4	0,2			
J	mean	3,7	3,9	3,7			
	std dev	1,7	1,5	1,5			
K	mean	4,3	4,8	4,9			
	std dev	2,1	1,7	1,5			
L	mean	2,2	1,6	1,7			
	std dev	1,3	0,6	0,5			
M	mean	2,4	2,0	1,7			
	std dev	1,4	1,2	1,1			
N	mean	2,4	2,2	2,0			
	std dev	1,2	0,7	0,3			

PANEL H

		DAM vs WEIR			WEIR vs DAM		
		ITERATION			ITERATION		
		1	2	3	1	2	3
	n	22	22	22	22	22	22
A	mean	3,0	2,5	2,3	2,6	2,2	2,0
	std dev	1,4	0,9	0,6	1,5	0,6	0,5
B	mean	3,5	3,6	3,6	5,1	5,0	5,0
	std dev	1,4	1,1	0,8	1,3	0,6	0,5
C	mean	4,9	4,9	5,0	5,5	5,6	5,7
	std dev	1,3	0,9	0,6	1,2	0,9	0,8
D	mean	4,6	4,4	4,2	3,5	3,4	3,5
	std dev	1,8	1,4	1,2	1,3	1,0	0,9
E	mean	2,7	2,2	2,1	3,9	3,7	3,6
	std dev	1,2	0,8	0,5	1,3	0,8	0,6
F	mean	4,4	4,5	4,4	4,8	4,7	4,4
	std dev	1,8	1,3	1,1	1,6	1,1	1,2
G	mean	3,7	3,5	3,6			
	std dev	1,3	1,1	1,0			
H	mean	3,4	3,3	3,1			
	std dev	1,6	1,1	0,9			
I	mean	2,7	2,6	2,5			
	std dev	1,4	0,7	0,6			
J	mean	4,1	4,2	4,3			
	std dev	1,5	1,1	1,1			
K	mean	5,2	5,2	5,0			
	std dev	1,3	1,0	1,0			
L	mean	3,1	2,8	2,7			
	std dev	1,5	0,9	0,7			
M	mean	2,9	2,5	2,5			
	std dev	1,4	0,8	0,7			
N	mean	2,6	2,4	2,3			
	std dev	1,5	1,1	0,9			

PANEL I

		DAM vs WEIR			WEIR vs DAM		
		ITERATION			ITERATION		
		1	2	3	1	2	3
	n	19	19	19	19	19	19
A	mean	2,9	2,6	2,5	2,5	2,1	2,1
	std dev	1,6	1,5	1,5	1,1	0,7	0,3
B	mean	3,8	3,9	3,8	4,6	5,2	5,1
	std dev	1,8	1,6	1,6	1,5	1,2	1,2
C	mean	4,4	4,5	4,3	5,5	6,1	5,9
	std dev	1,7	1,4	1,3	1,6	1,0	1,0
D	mean	4,3	4,4	4,5	3,3	3,4	3,3
	std dev	1,6	1,4	1,2	1,5	1,2	1,0
E	mean	2,7	2,4	2,3	4,3	4,2	4,0
	std dev	1,2	0,8	0,7	1,6	1,3	1,1
F	mean	4,3	4,4	4,3	4,1	4,3	4,0
	std dev	1,7	1,3	1,4	1,7	1,3	1,3
G	mean	3,5	3,3	3,1			
	std dev	1,6	1,3	0,8			
H	mean	3,4	3,3	3,2			
	std dev	1,3	1,1	0,9			
I	mean	2,4	2,4	2,3			
	std dev	1,2	0,8	0,8			
J	mean	3,8	3,7	3,9			
	std dev	1,4	1,2	0,9			
K	mean	4,7	5,1	5,2			
	std dev	1,3	1,1	0,8			
L	mean	2,7	2,6	2,4			
	std dev	1,2	0,9	0,7			
M	mean	2,6	2,6	2,6			
	std dev	1,3	1,3	1,2			
N	mean	3,0	2,6	2,3			
	std dev	1,7	1,2	1,0			

PANEL J

		DAM vs WEIR			WEIR vs DAM			
		ITERATION			ITERATION			
		1	2	3	1	2	3	
	n		7	7	7	**	7	7
A	mean	3,3	3,0	3,0	2,1	2,0		
	std dev	1,8	1,7	1,4	0,3	0,0		
B	mean	3,7	4,1	4,1	3,7	4,1		
	std dev	2,1	1,8	1,6	1,3	1,7		
C	mean	4,1	4,1	4,4	6,4	6,4		
	std dev	1,5	1,0	0,9	0,5	0,5		
D	mean	5,6	5,9	6,1	1,7	1,7		
	std dev	1,3	1,1	1,1	0,7	0,7		
E	mean	3,0	2,7	2,6	4,6	4,6		
	std dev	1,3	1,2	0,5	1,6	1,6		
F	mean	4,9	5,0	5,0	2,7	2,7		
	std dev	1,6	1,5	1,4	0,9	0,9		
G	mean	3,1	3,0	3,1				
	std dev	1,6	1,6	1,5				
H	mean	3,9	3,9	3,7				
	std dev	1,6	1,4	1,0				
I	mean	4,3	4,1	4,1				
	std dev	1,7	1,1	1,1				
J	mean	4,0	3,9	3,7				
	std dev	1,6	1,6	1,3				
K	mean	5,3	5,4	5,7				
	std dev	1,7	1,4	1,3				
L	mean	4,6	4,7	4,7				
	std dev	1,0	0,9	0,9				
M	mean	4,0	4,0	4,1				
	std dev	1,5	1,1	1,2				
N	mean	4,3	4,0	4,0				
	std dev	1,2	1,1	1,1				

APPENDIX N
Distributions of Impact Ratings for Third Iteration in Case Study 4

PART 1: DAM vs WEIR

BENEFIT A: Reduces additional costs to consumers

PANEL:	A	B	C	D	E
7	.	.	.	.	*
6	*	*	.	*****	****
5	*	**	*****	**	.
4	.	*	***	***	**********
3	*******	****	*	***	*
2	*****	**	*	**	*
1	*	.	*	.	.

BENEFIT B: Reduces capital expenditure required

PANEL:	A	B	C	D	E
7	.	.	.	*	*
6	.	**	*	***	****
5	**	*	********	*	****
4	****	**	**	*****	*******
3	*********	**	.	****	*
2	.	***	.	*	.
1	.	.	.	.	.

BENEFIT C: Increases reliability of water supply

PANEL:	A	B	C	D	E
7	.	*	.	**	.
6	.	.	****	****	*
5	***	.	*****	****	*******
4	**	***	.	***	***
3	********	****	**	*	****
2	*	*	.	*	*
1	*	*	.	.	*

BENEFIT D: Provides hydro-power for additional R50m

PANEL:	A	B	C	D	E
7	.	.	.	.	.
6	*	.	*	*	*
5	*	**	*******	********	*****
4	*********	******	**	****	********
3	****	*	*	*	***
2	.	*	.	*	.
1	.	.	.	.	.

BENEFIT E: Avoids certain adverse impacts on residents

PANEL:	A	B	C	D	E
7	.	.	.	.	.
6	.	.	.	.	.
5	.	.	.	**	.
4	.	.	*	*	.
3	*******	**	*******	********	*
2	***	****	*	****	**********
1	*****	****	**	.	******

```
                 BENEFIT F:  Conserves lower reaches of valley
PANEL:   A                  B                  C                  D                  E
-----------------------------------------------------------------------------------------------
    7    .                  *                  .                  *                  *
    6    .                  ****               *                  *                  **
    5    *****              ****               *****              ******             *******
    4    ***                *                  *****              ***                *******
    3    ******             .                  .                  ****               .
    2    *                  .                  .                  .                  .
    1    .                  .                  .                  .                  .
-----------------------------------------------------------------------------------------------

                 BENEFIT G:  Conserves certain agricultural lands
PANEL:   A                  B                  C                  D                  E
-----------------------------------------------------------------------------------------------
    7    .                  .                  .                  *                  .
    6    .                  .                  .                  *                  .
    5    .                  *                  ****               **                 *
    4    *                  *                  **                 **                 *
    3    ********           *                  ****               ********           ***********
    2    ****               *****              .                  *                  ***
    1    **                 **                 *                  .                  *
-----------------------------------------------------------------------------------------------

                 BENEFIT H:  Conserves certain recreational resources
PANEL:   A                  B                  C                  D                  E
-----------------------------------------------------------------------------------------------
    7    .                  .                  .                  .                  .
    6    .                  *                  .                  .                  .
    5    **                 ***                ****               .                  *
    4    *******            *                  **                 *                  ***
    3    *****              ***                *****              ***********        *********
    2    *                  **                 .                  *                  **
    1    .                  .                  .                  **                 **
-----------------------------------------------------------------------------------------------

                 BENEFIT I:  Opportunity to improve economic conditions
PANEL:   A                  B                  C                  D                  E
-----------------------------------------------------------------------------------------------
    7    .                  .                  .                  .                  .
    6    .                  .                  .                  .                  .
    5    .                  .                  .                  .                  *
    4    .                  .                  *                  .                  .
    3    ***                .                  **                 ****               *
    2    *********          *****              ****               *********          ****
    1    ***                *****              ****               **                 ***********
-----------------------------------------------------------------------------------------------

                 BENEFIT J:  Avoids certain aesthetic impacts
PANEL:   A                  B                  C                  D                  E
-----------------------------------------------------------------------------------------------
    7    .                  .                  .                  .                  .
    6    .                  *                  .                  .                  **
    5    ****               **                 ******             ***                *****
    4    ***                ******             **                 ********           ***
    3    ******             *                  ***                ****               *****
    2    **                 .                  .                  .                  **
    1    .                  .                  .                  .                  .
-----------------------------------------------------------------------------------------------

                 BENEFIT K:  Minimises impacts on Palmiet estuary
PANEL:   A                  B                  C                  D                  E
-----------------------------------------------------------------------------------------------
    7    .                  .                  *                  .                  *
    6    **                 *****              ***                *****              *********
    5    ****               ****               *****              ******             *****
    4    *****              *                  *                  ****               .
    3    ****               .                  *                  .                  *
    2    .                  .                  .                  .                  .
    1    .                  .                  .                  .                  *
-----------------------------------------------------------------------------------------------
```

BENEFIT L: Improves fire-fighting capability

PANEL:	A	B	C	D	E
7	.	.	.	.	.
6	.	.	.	**	.
5	*	.	**	***	.
4	***	.	*****	*****	.
3	*********	****	***	***	******
2	**	****	*	*	**********
1	.	**	.	*	*

BENEFIT M: Increases opportunities for flat-water recreation

PANEL:	A	B	C	D	E
7	.	.	.	.	.
6	.	.	.	*	.
5	.	***	*	**	**
4	*	.	*	**	.
3	**********	***	***	*******	*
2	****	*	****	**	**********
1	.	***	**	*	****

BENEFIT N: Increases opportunities for production of biotic resources

PANEL:	A	B	C	D	E
7	.	.	.	.	.
6	.	.	.	*	.
5	.	.	.	*	*
4	***	.	***	******	*****
3	********	**	*****	****	*
2	**	******	***	*	********
1	**	**	.	**	**

PART 1: DAM vs WEIR (cont)
PANELS F to I: SHORT COURSES AND EGS STUDENTS

BENEFIT A: Reduces additional costs to consumers

PANEL:	F	G	H	I	J
7	.	.	.	*	.
6	.	.	.	*	*
5	.	*	.	.	.
4	***	.	*	*	*
3	****	**	******	*	*
2	.	**************	**************	************	****
1	***********	*	*	***	.

BENEFIT B: Reduces capital expenditure required

PANEL:	F	G	H	I	J
7	.	.	.	.	.
6	***	*	.	******	***
5	**	*****	**	.	.
4	*********	*******	***********	*	.
3	****	**	*******	*********	***
2	.	**	**	**	*
1	.	*	.	*	.

BENEFIT C: Increases reliability of water supply

PANEL:	F	G	H	I	J
7	.	.	.	*	.
6	******	****	***	****	*
5	********	**	***************	***	**
4	***	********	**	***	***
3	*	*	*	********	*
2	.	***	.	.	.
1	.	.	.	.	.

BENEFIT D: Provides hydro-power for additional R50m

PANEL:	F	G	H	I	J
7	.	.	.	.	****
6	*	.	*	****	*
5	****	*	*************	*******	*
4	*******	***********	*	*****	*
3	******	***	*****	*	.
2	.	**	*	**	.
1	.	*	*	.	.

BENEFIT E: Avoids certain adverse impacts on residents

PANEL:	F	G	H	I	J
7	.	.	.	.	.
6	.	.	.	.	.
5	.	.	.	.	.
4	.	.	.	*	.
3	*	****	****	******	****
2	************	*************	****************	**********	***
1	*****	*	**	**	.

BENEFIT F: Conserves lower reaches of valley

PANEL:	F	G	H	I	J
7	*	***	.	*	.
6	*	.	****	*	****
5	****	*	*******	*********	*
4	**	*******	*****	**	*
3	*	*****	*****	***	.
2	********	**	*	***	*
1	*	.	.	.	.

BENEFIT G: Conserves certain agricultural lands

PANEL:	F	G	H	I	J
7	.	.	.	.	.
6	.	.	.	.	.
5	*	**	***	*	**
4	.	.	*************	***	*
3	**	**	*****	************	*
2	************	************	**	**	
1	***	**	**	*	*

BENEFIT H: Conserves certain recreational resources

PANEL:	F	G	H	I	J
7	.	.	.	.	.
6	.	.	.	.	.
5	*	.	***	*	**
4	.	.	.	*******	**
3	*	*******	****************	*****	**
2	************	********	**	******	*
1	****	***	*	.	.

BENEFIT I: Opportunity to improve economic conditions

PANEL:	F	G	H	I	J
7	.	.	.	.	.
6	.	.	.	.	.
5	.	.	.	.	****
4	.	.	.	**	*
3	***	.	************	****	*
2	*************	****************	*********	***********	*
1	**	*	*	**	.

BENEFIT J: Avoids certain aesthetic impacts

PANEL:	F	G	H	I	J
7				*	
6	*	***			*
5	**	**	**************	*	*
4	*********	*****	***	*************	*
3	*****	**	****	***	***
2	*	******		*	*
1			*		

BENEFIT K: Minimises impacts on Palmiet estuary

PANEL:	F	G	H	I	J
7	*	**	*	*	**
6	********	******	*****	******	***
5	*****	*****	***********	********	*
4	*	*	***	****	
3	**	**	**		*
2	*	**			
1					

BENEFIT L: Improves fire-fighting capability

PANEL:	F	G	H	I	J
7					
6					**
5	**				*
4			****	*	****
3	***		********	******	
2	************	************	**********	***********	
1	*	******		*	

BENEFIT M: Increases opportunities for flat-water recreation

PANEL:	F	G	H	I	J
7					
6		*		*	*
5					**
4			**	*	**
3	***		********	**********	*
2	**********	********	***********	**	*
1	*****	*********	*	*****	

BENEFIT N: Increases opportunities for production of biotic resources

PANEL:	F	G	H	I	J
7					
6					
5	**				***
4	**		*	***	**
3	*	*	*********	****	*
2	************	****************	*******	*******	*
1	*	*	*****	*****	

PART 2: WEIR vs DAM

BENEFIT A: Avoids adverse impacts on residents

PANEL:	A	B	C	D	E
7	.	.	.	.	.
6	.	.	.	*	.
5	*	.	.	.	.
4	.	.	.	.	.
3	******	.	**	*****	**
2	******	******	*******	******	*********
1	**	****	**	***	******

BENEFIT B: Avoids certain aesthetic impacts

PANEL:	A	B	C	D	E
7	*****	.	.	.	.
6	******	******	.	.	****
5	**	***	**	*******	*******
4	**	.	******	*******	***
3	.	.	***	*	*
2	.	.	.	.	**
1	.	*	.	.	.

BENEFIT C: Conserves more of the natural environment

PANEL:	A	B	C	D	E
7	***********	*******	*	.	********
6	***	**	***	***********	******
5	.	.	*******	***	**
4	.	.	.	*	*
3	.	.	.	.	.
2	*	.	.	.	.
1	.	*	.	.	.

BENEFIT D: Conserves agricultural lands

PANEL:	A	B	C	D	E
7	.	.	.	*	.
6	*	.	.	*	.
5	*	.	*	*	*
4	.	*	******	*****	***
3	**********	**	***	****	********
2	***	******	.	***	**
1	.	*	*	.	***

BENEFIT E: Conserves scientific and educational resources

PANEL:	A	B	C	D	E
7	**	.	.	.	.
6	*	*****	*	*****	**
5	******	.	******	****	*****
4	*****	*	***	*****	*******
3	*	***	*	*	***
2	.	*	.	.	.
1	.	.	.	.	.

BENEFIT F: Reduces risk of extreme events affecting estuary

PANEL:	A	B	C	D	E
7	.	.	.	.	.
6	***	*	.	**	.
5	.	***	**	********	**
4	******	***	*******	*	********
3	****	*	*	**	*
2	**	*	*	**	***
1	.	*	.	.	***

PART 2: WEIR vs DAM (cont)

BENEFIT A: Avoids adverse impacts on residents

PANEL:	F	G	H	I	J
7	.	.	.	.	.
6	.	.	.	.	.
5	.	.	.	.	.
4	.	.	.	.	.
3	***	****	***	**	.
2	*************	*************	*****************	*****************	*******
1	**	*	**	.	.

BENEFIT B: Avoids certain aesthetic impacts

PANEL:	F	G	H	I	J
7	.	.	.	*	*
6	****	*	***	********	.
5	**********	*********	*****************	***	***
4	***	****	**	******	.
3	.	*	.	.	*
2	*	**	.	*	**
1	.	*	.	.	.

BENEFIT C: Conserves more of the natural environment

PANEL:	F	G	H	I	J
7	*****************		********	**	******* ***
6	.	********	*************	******	****
5	*	.	*****	****	.
4	.	**	**	**	.
3	.	.	.	.	.
2	.	.	.	.	.
1	.	.	.	.	.

BENEFIT D: Conserves agricultural lands

PANEL:	F	G	H	I	J
7	.	.	.	.	.
6	.	.	.	.	.
5	.	.	**	.	.
4	.	.	***********	***********	
3	****	*******	****	***	*
2	**********	********	*****	****	***
1	****	***	.	*	***

BENEFIT E: Conserves scientific and educational resources

PANEL:	F	G	H	I	J
7	******	.	.	.	*
6	*********	****	.	**	*
5	**	***********	.	***	**
4	*	*	**************	*********	*
3	.	**	*******	***	*
2	.	.	*	**	*
1	.	.	.	.	.

BENEFIT F: Reduces risk of extreme events affecting estuary

PANEL:	F	G	H	I	J
7	*	**	.	.	.
6	*	*	***	*	.
5	*	**	***********	********	.
4	********	*****	***	****	**
3	******	***	**	***	*
2	*	*****	***	**	****
1	.	.	.	*	.

PART 3: DAM vs DESALINATION

BENEFIT A: Reduces additional costs to consumers

PANEL:	A	B	C	D	E
7	.	*	*	*	**
6	.	.	**	***	**
5	*******	**	***	*****	********
4	***	*****	*****	***	**
3	.	****	.	**	**
2	.	*	.	*	*
1	.	.	.	.	.

BENEFIT B: Achieves greater return on capital

PANEL:	A	B	C	D	E
7	.	*	.	*	*
6	.	.	**	*	**********
5	****	*	********	***	**
4	****	*****	*	********	***
3	**	******	.	**	*
2	.	.	.	.	.
1	.	.	.	.	.

BENEFIT C: Time to improve desalination technology

PANEL:	A	B	C	D	E
7	.	.	*	*	.
6	.	.	.	****	****
5	****	.	******	******	*******
4	**	***	***	**	**
3	**	*******	*	**	***
2	**	***	.	.	.
1	.	.	.	.	*

BENEFIT D: Conserves energy resources

PANEL:	A	B	C	D	E
7	.	*	.	*	**
6	*	**	**	**	*****
5	**	****	********	********	******
4	*****	*****	.	****	****
3	**	*	*	.	.
2	.	.	.	.	.
1	.	.	.	.	.

BENEFIT E: Increases reliability of water supply

PANEL:	A	B	C	D	E
7	.	.	.	*	.
6	.	.	***	*****	**
5	*	*	*****	******	**
4	**	**********	.	.	********
3	*******	.	***	**	***
2	.	.	.	*	**
1	.	**	.	.	.

BENEFIT F: Opportunities for flat-water recreation

PANEL:	A	B	C	D	E
7	.	.	.	.	.
6	.	**	.	.	.
5	.	.	.	**	**
4	.	.	*	**	.
3	**	.	*****	********	***
2	***	****	****	***	********
1	*****	*******	*	.	****

PART 4: DESALINATION VS DAM

BENEFIT A: Hastens development of more secure water supplies

PANEL:	A	B	C	D	E
7	***	*********	**	******	*
6	****	*	*****	****	*
5	***	**	***	**	***
4	.	.	.	***	*********
3	.	.	.	.	**
2	.	.	*	.	*
1	.	*	.	.	.

BENEFIT B: Enhances SA's international reputation

PANEL:	A	B	C	D	E
7	.	.	.	.	.
6	.	.	.	.	.
5	.	.	.	****	.
4	*****	.	.	*****	*
3	***	**	*	****	*******
2	**	**********	******	**	*******
1	.	*	****	.	**

BENEFIT C: Stimulates regional economic development

PANEL:	A	B	C	D	E
7	.	.	.	.	.
6	.	*	.	.	*
5	**	*****	********	*******	.
4	*****	**	.	*****	****
3	***	*****	*	***	*********
2	.	.	*	.	***
1	.	.	*	.	.

BENEFIT D: Conserves natural resources in Kogelberg forest

PANEL:	A	B	C	D	E
7	******	**********	**	*****	**********
6	****	*	*******	*****	****
5	.	*	*	****	***
4	.	*	*	*	.
3	.	.	.	.	.
2	.	.	.	.	.
1	.	.	.	.	.

BENEFIT E: Conserves scientific and educational resources

PANEL:	A	B	C	D	E
7	*	.	.	.	.
6	**	****	*****	****	****
5	******	****	***	*******	**
4	*	****	*	***	**********
3	.	*	**	*	*
2	.	.	.	.	.
1	.	.	.	.	.

BENEFIT F: Conserves agricultural lands

PANEL:	A	B	C	D	E
7	.	*	.	**	.
6	**	.	.	*	*
5	****	****	**	**	.
4	**	*	****	********	*
3	*	****	****	.	***********
2	.	***	.	**	****
1	*	.	*	.	.

```
              BENEFIT G:  Opportunities to increase productivity of certain resources
PANEL:   A              B                 C                 D                 E
-------------------------------------------------------------------------------------
  7      .              .                 .                 .                 .
  6      .              .                 .                 .                 .
  5      .              .                 ***               **                **
  4      *              **                *****             *****             ***
  3      ***            *                 *                 *****             ***
  2      **             ****              **                **                *******
  1      ****           ******            .                 *                 **
-------------------------------------------------------------------------------------
```

```
              BENEFIT H:  Improves fire-fighting capability
PANEL:   A              B                 C                 D                 E
-------------------------------------------------------------------------------------
  7      .              .                 .                 .                 .
  6      .              .                 .                 *                 .
  5      .              .                 .                 **                .
  4      .              .                 ***               *******           .
  3      ******         *                 ******            *                 ***
  2      **             ********          **                ****              ***********
  1      **             ****              .                 .                 ***
-------------------------------------------------------------------------------------
```

```
              BENEFIT I:  Improves economic conditions - Kleinmond/Strand
PANEL:   A              B                 C                 D                 E
-------------------------------------------------------------------------------------
  7      .              .                 .                 .                 .
  6      .              .                 .                 .                 .
  5      .              .                 .                 .                 *
  4      .              .                 *                 **                .
  3      *              .                 *                 ********          **
  2      ********       **                ******            ***               ******
  1      *              ***********       ***               **                ********
-------------------------------------------------------------------------------------
```

BENEFIT G: Maintains natural conditions in estuary

PANEL:	A	B	C	D	E
7	.	*	**	.	.
6	*******	*****	**	****	**
5	**	******	******	**********	***********
4	.	.	.	*	**
3	*	*	*	.	*
2	.	.	.	.	*
1	.	.	.	.	.

BENEFIT H: Conserves aesthetic quality of Kogelberg forest

PANEL:	A	B	C	D	E
7	.	.	**	**	**
6	**********	***	**	******	*****
5	.	********	******	******	*******
4	.	*	*	*	***
3	.	*	.	.	.
2	.	.	.	.	.
1	.	.	.	.	.

BENEFIT I: Keeps future options open

PANEL:	A	B	C	D	E
7	***	***	*	*****	****
6	****	****	.	*******	.
5	**	****	****	*	******
4	.	*	****	.	***
3	*	.	*	*	***
2	.	*	*	*	*
1	.	.	.	.	.

BENEFIT J: Reduces fire hazard

PANEL:	A	B	C	D	E
7	.	.	.	*	.
6	.	.	.	****	.
5	***	*****	**	*	*
4	***	****	****	****	**
3	**	**	**	****	**********
2	*	**	***	*	***
1	*	.	.	.	*

BENEFIT K: Avoids adverse impacts on residents

PANEL:	A	B	C	D	E
7	.	.	.	.	.
6	.	.	.	*	.
5	.	.	.	*	.
4	.	.	.	***	.
3	**	*****	****	******	*
2	*******	********	******	**	*********
1	*	.	*	**	*******

BENEFIT L: Conserves recreational resources

PANEL:	A	B	C	D	E
7	.	**	.	.	.
6	.	***	.	.	.
5	*	**	*	.	**
4	*******	****	***	***********	***
3	*	**	*****	***	*****
2	.	.	**	*	*******
1	*	.	.	.	.

APPENDIX O

COMPARISONS OF THE IMPACTS IDENTIFIED BY THE INFANTA PANELS IN CASE STUDY 5

Introduction

Each of the two Infanta panels accomplished two iterations of impact identification for both positive and negative impacts before undertaking an evaluation of the relative significance of these impacts. Subsequently three research associates independently reviewed the four pairs of lists of impacts produced by the panels and made judgments as to which impact definitions of the two panels could be considered equivalent or reasonably comparable. The object was to determine the extent to which impact definitions produced by one panel would be recognizably similar to those of another panel, and whether those impact statements which were judged to be similar could be regarded as meaning essentially the same thing for the purpose of guiding assessments or evaluations.

There were no significant differences in the judgments of the three research associates as to which impact definitions corresponded and which had no counterpart. The results of this comparison are presented here in four parts:

- the first iteration of positive impacts
- the second iteration of positive impacts
- the first iteration of negative impacts
- the second iteration of negative impacts.

These lists are presented in the above order using the following format:

1. The first iteration of positive impacts by Panel 1, along with the equivalent impacts identified by Panel 2, followed by a listing of impacts identified by one panel for which there was judged to be no corresponding impact listed by the other panel.

2. The second iteration of positive impacts by both panels, compared in the same manner alluded to above. These impacts (which had been organized under banner headings by the project coordinators, followed by short statements which described the nature of the impact) are here arranged under "neutral" headings that were chosen by the principal researcher when comparing the results of the two panels.

3. The first iteration of negative impacts, presented as in 1 above.

4. The second iteration of negative impacts, presented as in 2 above.

Impacts identified by Panel 1 will be preceded by the number "1", and those of Panel 2 will be preceded by the number "2" (*e.g.*, 1A vs. 2A). (NOTE: Some of the impacts were defined by the panels in sentence form, others in phrases only.)

Positive Impacts, First Iteration

Impacts Regarded as Equivalent

1A = 2G(c)

1A: The reservoir would provide an improved water supply to existing property owners to replace the present unreliable system.

2G(c): A more reliable water supply will benefit current residents.

1B = 2F

1B: The improvement and expansion of local amenities (*e.g.* shops and recreational facilities, especially an increased swimming area and separation of boaters and bathers).

2F: Recreational facilities (*e.g.*, tidal pool, boat ramps, picnicking area) will benefit the village (*e.g.*, the tidal pool will provide safer, larger swimming area).

1C + 1D = 2A

1C: The provision of employment for local and other labour during building operations.

1D: The provision of formal and informal employment after the township development for the local community and others in an economically inactive area.

2A: The development will provide seasonal employment opportunities for farm labourers and temporary employment for construction workers.

1E + 1N = 2B

1E: Increasing the supply of holiday accommodation and recreational facilities will help meet regional recreational needs.

1N: This relatively undeveloped resort would be better used in the light of the loss of local resorts due to the South African Defence Force development at De Hoop.

2B: The development will provide further needed holiday accommodation along the coast in relatively unspoilt areas, especially as a result of the loss of other potential sites.

1F = 2E

1F: The proposed development will provide attractive permanent accommodation for retired people.

2E: Prospective buyers will be provided with superior sites: north facing, good views, sheltered from the south-easterly wind in the summer season.

1G = 2D

1G: Property values in the area will increase.

2D: The development will increase property values.

1H = 2G(a)

1H: The present refuse disposal system will be improved by removal of the present dump to a more remote area.

2G(a): Improved litter disposal will benefit current residents.

1J = 2G(b)

1J: Roads in the area will be improved.

2G(b): An improved entrance road will benefit current residents.

1K = 2I

1K: The provision of local authority erven for better social services and increased local authority spending to upgrade facilities, *e.g.* picnic areas.

2I: The rates and taxes from the new development will permit local authority to make improvements, *e.g.* to improve and manage river area, to manage fynbos on remainder of Erf 134, and provide improved public amenities and services.

Impacts Identified by One Panel Only

1I: Recreational pressure will be taken off other more sensitive coastal areas by developing this already disturbed site.

1L: The inclusion of the area in the ESCOM electricity network system could become a viable proposition by an increase in users.

1M: The economy of the surrounding urban areas would benefit slightly during peak holiday seasons.

2C: The holiday population will provide chances for local young farmers to find spouses.

2H: The aesthetic character of Infanta will be improved by a centralized water supply (*i.e.*, removal of water towers now projecting above houses) and by groupings of housing.

2J: Increased population will stimulate greater public interest in conservation and will encourage further studies into rare species.

Positive Impacts, Second Iteration

Impacts Regarded as Equivalent

1A = 2A + 2B: BETTER EMPLOYMENT PROSPECTS

1A: Increased Employment Opportunities

Employment opportunities for local and other labour would arise during the construction phase.

There would be increased formal (*e.g.* shop owners) and informal (*e.g.* sale of braaiwood) employment opportunities in the Infanta area.

The new township would increase holiday employment opportunities for farm families.

2A: Permanent Employment

Development will provide seasonal employment for local" Coloured" population.

2B: Temporary Employment

The development will provide temporary employment for construction workers.

1B = 2I: BETTER INFRASTRUCTURE AND SERVICES

1B: Improvements in Local Infrastructure and Services

The reservoir would provide an improved water supply to the existing Infanta residents.

Amenities such as shops may be built.

The road to Infanta and in the village may be upgraded.

The removal of the rubbish dump to a more remote area will reduce the health hazard and be less visible to local residents.

The inclusion of the area in the ESCOM electricity system could become a viable proposition by an increase in users.

2I: Increased Services

The rates and taxes from the new development will permit the local authority to improve area facilities, provide improved public amenities and services, improve litter disposal, and improve the entrance road.

1C = 2G: BETTER RECREATIONAL FACILITIES

1C: Additional Recreational Facilities

The tidal pool will provide additional safe swimming areas for all holiday makers.

More public open space will reduce pressure on the beach and provide additional area for day visitors.

2G: New Recreational Facilities

Recreational facilities will benefit the village, *e.g.*, tidal pool will provide safer, larger swimming area.

1D = 2E + 2F: STIMULUS TO REGIONAL ECONOMY

1D: Stimulation of Regional Economy

The economy of the surrounding urban areas would benefit, especially during peak holiday seasons.

Property values in the area will increase.

2E: Multiplier Effect

The development will provide a general economic stimulus to the region.

2F: Property Values Increased

The development will increase property values.

1E = 2D: MORE RECREATIONAL HOUSING

1E: Increased Opportunities for Prospective Home Owners and Holiday Makers

The new township will provide prospective holiday home owners and people seeking retirement homes with additional opportunities to own a home at the sea.

This relatively undeveloped resort would be better used in the light of the loss of local resorts due to the South African Defense Force development at De Hoop.

2D: Suitable Holiday Sites

The development will meet a demand for holiday sites that are north-facing, sheltered and with good views along the coast in relatively unspoilt area, especially as a result of loss of other potential areas (*e.g.*, "Skipskop").

1F = 2K: ECOLOGICAL ADVANTAGES

1F: Alleviate Recreational Pressure in Sensitive Coastal Areas

Recreational pressure will be taken off other more ecologically sensitive areas by developing this already disturbed site.

2K: Ecology Unaffected

The development will not affect any valued plant communities or rare vegetation types.

Impacts Identified by One Panel Only

2C: Courtship Opportunities

The holiday population will provide improved chances for local young farmers finding spouses.

2H: Improved Aesthetics

The aesthetic character of Infanta will be improved by reducing the necessity for water towers above houses and improving the entrance to Infanta with group housing.

2J: Conservation Awareness

Increased population will stimulate greater public interest in conservation and will encourage further ecological studies.

Negative Impacts, First Iteration

Impacts Regarded as Equivalent

1A = 2B

1A: Seepage from rubbish dump and septic tanks could pollute groundwater supplies.

2B: Groundwater supply may be contaminated from septic tank soakaways, farm fertilizers and pesticides and leachates from low-lying refuse tip sites.

1B + 1C = 2A

1B: Pumping of groundwater could reduce the supply or quality of water.

1C: The yield from boreholes may not be able to meet the demand at peak holiday periods.

2A: Groundwater supply may be inadequate.

1D + 1E + 1F + 1G = 2C

1D: Increased numbers of boats will place additional pressure on limited launching facilities at the Infanta slipway and bar harbour.

1E: Additional holiday makers will create crowding and congestion on the Infanta beach.

1F: Increased numbers of recreationists using the Infanta slipway and bathing area will result in conflict between different user groups and safety levels will be reduced.

1G: Increased recreational craft using the estuary will create conflict between water users.

2C: Existing coastal recreation facilities will become congested, *e.g.*, boat launching facilities, swimming area, beaches, and commonage.

1H = 2I

1H: Congestion on the commonage will worsen with increased numbers of fishermen using this area to park vehicles and trailers. This will result in a loss of open space for picnicking for day visitors.

2I: More vehicles will increase traffic and need for parking areas.

1I + 1K + 1L + 1M = 2D

1I: Increased exploitation by holiday makers will cause the decline of edible shellfish and bait organisms.

1K: There will be an increase in the pressure on line fishing.

1L: The Zostera beds and saltmarshes will be adversely affected by the increased number of boats launching and mooring in the area.

1M: Increased bait collecting pressure will result in the disturbance of the fragile saltmarsh ecosystem.

2D: Marine and estuarine life would be subjected to greater exploitation, *e.g.*, bait organisms, shellfish, tidal pool organisms, and fish stocks.

1J = 2G + 2Z

1J: Construction of the tidal pool will adversely affect the marine ecology and beauty of the shoreline.

2G: The tidal pool could prove expensive to maintain and become degraded.

2Z: Localised drift sand could occur around the tidal pool.

1O = 2N

1O: Loss of lowland fynbos and its associated habitat due to site clearance.

2N: An area of good quality fynbos will be lost.

1P + 1Z = 2V

1P: Construction activities will lead to the spread of alien vegetation.

1Z: A housing development adjacent to the private nature reserve will render it vulnerable to intrusion and less viable as a nature reserve.

2V: Local private nature reserve may suffer trampling, fires, alien infestation and an invasion by Argentine ants.

1Q = 2DD

1Q: More people in the area will disturb birds and game.

2DD: Waterfowl nesting/feeding areas and mud-flats may be destroyed by greater recreational pressure.

1W = 2F

1W: Access to the tidal pool will require considerable modification to the coast.

2F: Boulder beaches, an uncommon feature of S.A.'s coastline, would be modified by the tidal pool.

1X + 1EE = 2M

1X: Services provided for the new township will result in additional costs to present Infanta property owners.

1EE: The development may lead to a demand for a high level of services such as tarred roads, water, sewerage, electricity, which would be expensive for the local authority and the residents.

2M: Rates to existing residents will increase to pay for unwanted services.

1Y = 2O

1Y: Increased numbers in the area may pose a threat to security in Infanta.

2O: Crime could increase.

<u>1AA = 2X</u>

1AA: Siting of a rubbish dump on Erf 134 will reduce the aesthetic quality of the private nature reserve.

2X: The rubbish dump will be a source of wind-blown litter.

<u>1BB = 2H</u>

1BB: The reservoir and buildings on the hill at Infanta will impair scenic views.

2H: The view from Witsands and the river/beach would be spoilt.

<u>1CC + 1DD + 1FF = 2P</u>

1CC: The extension of Infanta is likely to result in the development of holiday resort infrastructure (*e.g.*, cafes and hotels) which will draw other users and entrepreneurs to the area.

1DD: Expansion at Infanta will exacerbate the creep of coastal township development.

1FF: The proposed development may increase the attractiveness of the Infanta area for further development.

2P: The project could stimulate further developments that might be inappropriate to the area.

<u>Impacts Identified by One Panel Only</u>

1N: Additional skiboats using the estuary will increase sediment and bank disturbance.

1R: More garbage will be generated.

1S: The waterpump which feeds the reservoir will cause noise and air pollution.

1T: No ablution facilities near the tidal pool could result in a health hazard.

1U: The exposed dump on Erf 134 could pose a health hazard.

1V: The building of the tidal pool will destroy archaeological sites and shell middens.

2E: Whales would be disturbed by increased boating.

2J: The rustic character of the existing township will be lost.

2K: The unspoilt and uncrowded character of the surrounding coastal area will be lost.

2L: Allowing this development might inhibit/preclude development in more suitable areas.

2Q: The project will waste resources that could be put to better use (*e.g.*, low-income housing, nature conservation, roads).

2R: Erosion will occur where vegetation is disturbed in thin soils.

2S: Owners of Erf 107 will have trespassers crossing from Erf 134 to the shoreline.

2T: Local roads from the N2 will require more maintenance.

2U: More regulations will be imposed on residents by local government.

2W: Lowering of water table may kill off some natural vegetation.

2Y: Houses in low-lying areas may be damp.

2AA: There may be threatened plant species in the reasonably wet lowland area.

2BB: Houses will be scattered and not contiguous to Infanta.

2CC: Roads and graded sites will scar hillside.

2EE: Construction noise and disruption will affect present residents and holiday-makers.

2FF: The new development might attract the "wrong type" of people (*i.e.*, insensitive to nature).

Negative Impacts, Second Iteration

Impacts Regarded as Equivalent

1A = 2F: RECREATIONAL CONGESTION

1A: Overcrowding of Recreational Facilities

Increased numbers of boats will place additional pressure on the limited launching facilities at Infanta slipway and bar harbour.

Additional holiday makers will create overcrowding and congestion on the Infanta beach and slipway which will result in conflict between different user groups.

Increased number of recreational craft using the estuary will create conflict between water users.

Congestion on the commonage will worsen with increased number of fishermen using this area to park vehicles and trailers. This will result in a loss of open space for picnickers.

2F: Congestion Effects

The uncrowded nature of the surrounding coastal area will be diminished.

Existing coastal recreation facilities will become congested (*e.g.*, beaches, boat launching facilities, roads and parking).

1B + 1L = 2G: GROUNDWATER AND POLLUTION PROBLEMS

1B: Health Hazards

If no ablution facilities are provided near the tidal pool a health hazard may arise.

The exposed rubbish dumps on Erf 134 could pose a health hazard.

Leachates from the rubbish dumps and seepage from septic tanks could contaminate the water supply.

1L: Yield from Boreholes may be Insufficient

The yield from boreholes may not be able to meet the demand at peak periods, necessitating alternative water supply.

2G: Groundwater Problems

Groundwater supply may prove inadequate or become contaminated from soakaways or leachates from the refuse site.

1D + 1H + 1J + 1K = 2A + 2C + 2E + 2I: DEGRADED AESTHETICS, SECURITY, AND COMMUNITY CHARACTER

1D: Impaired Aesthetic Quality

Scarring of landscape during construction activities will be an eyesore.

Access to the tidal pool will require modifications to the natural beauty of the coastline.

The tidal pool and windbreak structures will diminish the natural beauty of the shoreline.

The siting of the rubbish dump on Erf 134 will reduce the aesthetic quality of the private nature reserve.

The reservoir and building on the hill will impair scenic views.

1H: Danger to Public Safety

Increased numbers of people in the area may pose a threat to the security at Infanta.

The risk of accidental fires would be increased.

The beach, slipway and bathing area will become less safe due to greater numbers of people and craft using the area.

1J: Change in Character of Existing Infanta Village

The extension of Infanta is likely to result in the development of holiday resort infrastructure (*e.g.*, cafe, petrol station and hotel), which will draw other users and entrepreneurs to the area.

The rustic fishing village character of Infanta will be lost for future generations.

The tranquil atmosphere of Infanta will be lost by noise intrusions such as that caused by the water pump.

1K: Loss of Scarce Undeveloped Coastal Areas to Uncontrolled Development Schemes

Expansion of Erf 134 will increase the potential for further development at Infanta and will exacerbate the spread of coastal township development.

Impetus will be given to further uncontrolled development before a regional master plan has been produced.

2A: Aesthetic Quality Impaired

A new development not contiguous with Infanta consisting of roads and houses scattered over the hillside will detract from the present quality of the village.

The project would stimulate further inappropriate development

2C: Effects of Tidal Pool

Tidal pool construction would modify boulder beaches (which are an uncommon feature on the S.A. coast) and could result in localised drift sands.

The tidal pool could become degraded.

2E: Change in Community Character

The new development will attract people who are relatively insensitive to the area's natural attributes.

The development may also contribute to community problems such as trespassing and even crime.

2I: Suboptimal Location

A development at Infanta might inhibit or preclude developments in more suitable areas.

1E + 1F = 2H: LOSSES TO MARINE AND ESTUARINE SYSTEMS

1E: Exploitation of Marine Resources

Increased exploitation by holiday-makers will further reduce the numbers of large edible shellfish and reduce the population of bait organisms.

There will be an increase in the pressure on line fishing resources.

1F: Disturbance to Estuarine Environment

Increased numbers of boats being launched and anchoring in the estuary would adversely affect the saltmarshes and zostera beds.

Increased bait collecting pressure will result in the disturbance of the fragile saltmarsh ecosystem.

Additional skiboats using the estuary in the vicinity of the saltmarshes will increase sediment and bank disturbance.

2H: Biotic Disturbances

Marine and estuarine life will be subjected to greater disturbance and exploitation, *e.g.*, bait organisms, shellfish, tidal pool organisms, fish, whales, and waterfowl.

1I = 2D: HIGHER RATES AND MORE REGULATIONS

1I: Increased Cost to Local Inhabitants and Local Authority

The development may lead to a demand for a high level of services (*e.g.*, tarred roads, water, electricity, sewerage), which would be expensive to local inhabitants and the local authority.

The cost of the reservoir may be forced on the local authority if the development fails.

Services provided for the new township will result in additional costs to Infanta property owners.

2D: Rates and Regulations

Increased rates and new regulations would be imposed on residents by local government for providing services and maintenance of facilities (*e.g.*, tidal pool) beyond what is presently wanted or required.

<u>1G = 2B + 2J: Losses to Terrestrial Systems</u>

1G: Disturbance and Destruction of the Terrestrial Environment

Loss of lowland fynbos and its associated habitat due to site clearance.

Spread of alien vegetation due to construction activities.

Disturbance of birds and game by increased numbers of people in the area.

Erosion due to wind and run-off during the construction phase will result in a loss of top soil.

The housing development and access road to the dump will render the private nature reserve vulnerable to intrusion and consequently less viable.

2B: Soil and Vegetation Losses

Excavations and roads will reduce fynbos in the area and increase erosion.

A lowering water table may destroy indigenous vegetation, some of which may be threatened species.

2J: Damage to Nature Reserve

The local private nature reserve may suffer fires, trampling, infestation by alien vegetation and invasion by Argentine ants.

<u>Impacts Identified by One Panel Only</u>

1C: Loss of Archaeological Sites

Archaeological sites and shell middens would be lost during the construction of the pool

2K: Litter

The rubbish dump will be a source of wind-blown litter.

ILLUSTRATIVE MATERIAL

ILLUSTRATIVE MATERIAL

APPENDIX AA

Environmental Aspect Analysis - Case Study 1 (Groenrivier)

(Excerpted from Stauth, 1982b, pp.16-18)

ENVIRONMENTAL ASPECT ANALYSIS: GROENRIVIER SYSTEM

After having described the present biophysical and socioeconomic components of the system, an environmental aspect analysis was undertaken in which the potential utility of the system was assessed in order to identify the most promising management options. This was accomplished by determining a number of general uses to which the system's resources could be put (nine were selected), and then rating all aspects of the system which were relevant to each use. The rating was done by a small group of individuals who were familiar with a large number of other systems around the South African coast so that they could rate Groenrivier aspects against the average condition of these aspects elsewhere in the country.

The nine possible uses of estuarine resources considered were developments associated with (1) fisheries, (2) harbours, (3) transport, (4) mining, (5) forestry and agriculture, (6) industry, housing and commerce, (7) water storage, (8) recreation and tourism, and (9) conservation and scientific research. All aspects considered relevant to each use were defined and rated on a 7-point scale to indicate their condition or suitability relative to the average for other systems around the coast. The results are summarised as follows.

<u>Fisheries:</u> The potential contribution of this system to estuarine and marine fisheries is virtually nonexistent. Since there is rarely contact with the sea, plant nutrients are not transported to coastal waters and the estuary cannot serve as a nursery area for larval and juvenile stages of marine organisms. Conditions are also not suitable for aquaculture due to variable salinity, lack of freshwater, and other considerations.

<u>Harbours:</u> There are no sites physically suitable for harbours and anchorages, and in any case this area has very poor access to towns, industries, and transport networks.

<u>Transport:</u> The terrain in the estuarine zone is quite suitable for the construction of roads, railway lines, pipelines, and

powerlines. However, there is virtually no demand for these developments. The frequent fog conditions make the zone unfavourable for the establishment of an airport.

Mining: Potential for mining shell, sand, and gravel, and potential for salt production operations, is above average. The potential for mining valuable minerals (specifically diamonds) appears to be high.

Forestry and Agriculture: The suitability of the estuarine zone and catchment for forestry operations is nil. The agricultural potential of the estuarine zone and catchment is below average to low. there is no reclamation potential in the estuarine zone, and negligible potential for irrigation projects in the estuarine zone and catchment.

Industry, Housing and Commerce: Socioeconomic demand for new industries, homes and business is virtually nonexistent. There are suitable sites for such developments; however, the availability of freshwater for industrial and household consumption is totally inadequate. The potential of the estuarine and coastal zone to process and assimilate waste products is judged to be very low.

Water Storage: There are no suitable sites in the estuarine zone for barrage and other water storage schemes, and there are no sites in the catchment for dam construction. In addition, there is little demand for additional water storage capacity in the area to accommodate present uses (small stock and wheat farming).

Recreation and Tourism: The suitability of the estuarine zone for recreational activities is judged to be above average to high. However, there is little prospect of attracting a significant number of tourists to the area, at least for the foreseeable future. (As other areas become more congested, it seems probable that this area would appeal to more people.) The capacity to accommodate more recreationists and tourists (without incurring significant congestion effects) is rated above average to high.

Conservation and Scientific Research: The area's potential significance for species and ecosystem conservation is rated as above average to high. While there are no known rare or endangered species, there are several species which are endemic to Namaqualand. In addition, the lagoon is a unique ecosystem and the area contains relatively unspoiled ecosystems which are representative of this part of South Africa and which are presently not protected anywhere else. The significance of the area's aesthetic and pristine quality is rated high to exceptional. There appear to be no significant historical or cultural sites apart from potentially valuable strandloper midden deposits. Finally, the importance of the system's ecological functions to any conceivable socioeconomic developments is thought to be low.

Based on this analysis, the management options are to plan developments relating to mining, recreation, and conservation and scientific research.

ILLUSTRATIVE MATERIAL

APPENDIX BB

Required Value of Initial Year's Recreational Benefits to Exceed Value of Mining Development - Case Study 1 (Groenrivier)

(Excerpted from Stauth, 1982a, pp.114-116)

REQUIRED VALUE OF INITIAL YEAR'S RECREATIONAL BENEFITS TO EXCEED VALUE OF MINING DEVELOPMENT

The following table illustrates various values for the initial year's recreational benefits which would be required to exceed the present value of park costs and (foregone) net mining benefits if different assumptions are made regarding the appropriate discount rate and changes in the relative value of recreational benefits. For example, if the discount rate is 8%, and the real price of recreational benefits increases 4% per annum while the quantity demanded at the given price increases 7,5% per annum, then the present value of one Rand's worth of initial year's recreational benefits is R123,50. Since the present value of park costs and net mining benefits, discounted at 8%, is R27 538 000, the initial year's recreational benefits must be worth at least R222 977 for the park to be preferred over mining.

I = Rate of discount

R = Rate of price growth

G = Rate of demand growth

PV = Present value of one Rand's worth of recreational benefits

PVD = Present value of park costs and net mining benefits (millions)

BPI = Initial year's recreational benefits

(TIME HORIZON: 20 years mining;
50 years park)

I	R	G	PV	PVD	BPI
8%	4%	7,5%	R123,50	R27,5M	R222 977
8	4	10,0	150,50	27,5	182 972
8	4	12,5	212,40	27,5	129 633
8	5	7,5	167,80	27,5	164 087
8	5	10,0	201,60	27,5	136 592
8	5	12,5	287,50	27,5	95 780
8	6	7,5	230,90	27,5	119 255
8	6	10,0	272,90	27,5	100 887
8	6	12,5	392,60	27,5	70 127
9	4	7,5	93,40	24,6	263 895
9	4	10,0	115,10	24,6	214 046
9	4	12,5	160,70	24,6	153 368
9	5	7,5	124,90	24,6	197 347
9	5	10,0	152,10	24,6	162 020
9	5	12,5	214,70	24,6	114 742
9	6	7,5	169,30	24,6	145 574
9	6	10,0	203,20	24,6	121 232
9	6	12,5	289,90	24,6	84 987

I	R	G	PV	PVD	BPI
10%	4%	7,5	R 71,90	R22,3M	R310 580
10	4	10,0	89,50	22,3	249 612
10	4	12,5	123,40	22,3	181 072
10	5	7,5	94,60	22,3	236 184
10	5	10,0	116,60	22,3	191 665
10	5	12,5	162,80	22,3	137 255
10	6	7,5	126,20	22,3	176 988
10	6	10,0	153,70	22,3	145 376
10	6	12,5	217,10	22,3	102 913
10	0	0	10,00	22,3	2 234 000
10	0	2	12,50	22,3	1 787 200
10	0	4	16,30	22,3	1 370 552
10	0	6	22,40	22,3	997 321
10	1	0	11,10	22,3	2 012 613
10	1	2	14,30	22,3	1 562 238
10	1	4	19,10	22,3	1 169 634
10	1	6	27,00	22,3	827 407
10	2	0	12,50	22,3	1 787 200
10	2	2	16,40	22,3	1 362 195
10	2	4	22,70	22,3	984 141
10	2	6	33,20	22,3	672 892
10	3	0	14,20	22,3	1 573 239
10	3	2	19,20	22,3	1 163 542
10	3	4	27,30	22,3	818 315
10	3	6	41,60	22,3	537 019

ILLUSTRATIVE MATERIAL

APPENDIX CC

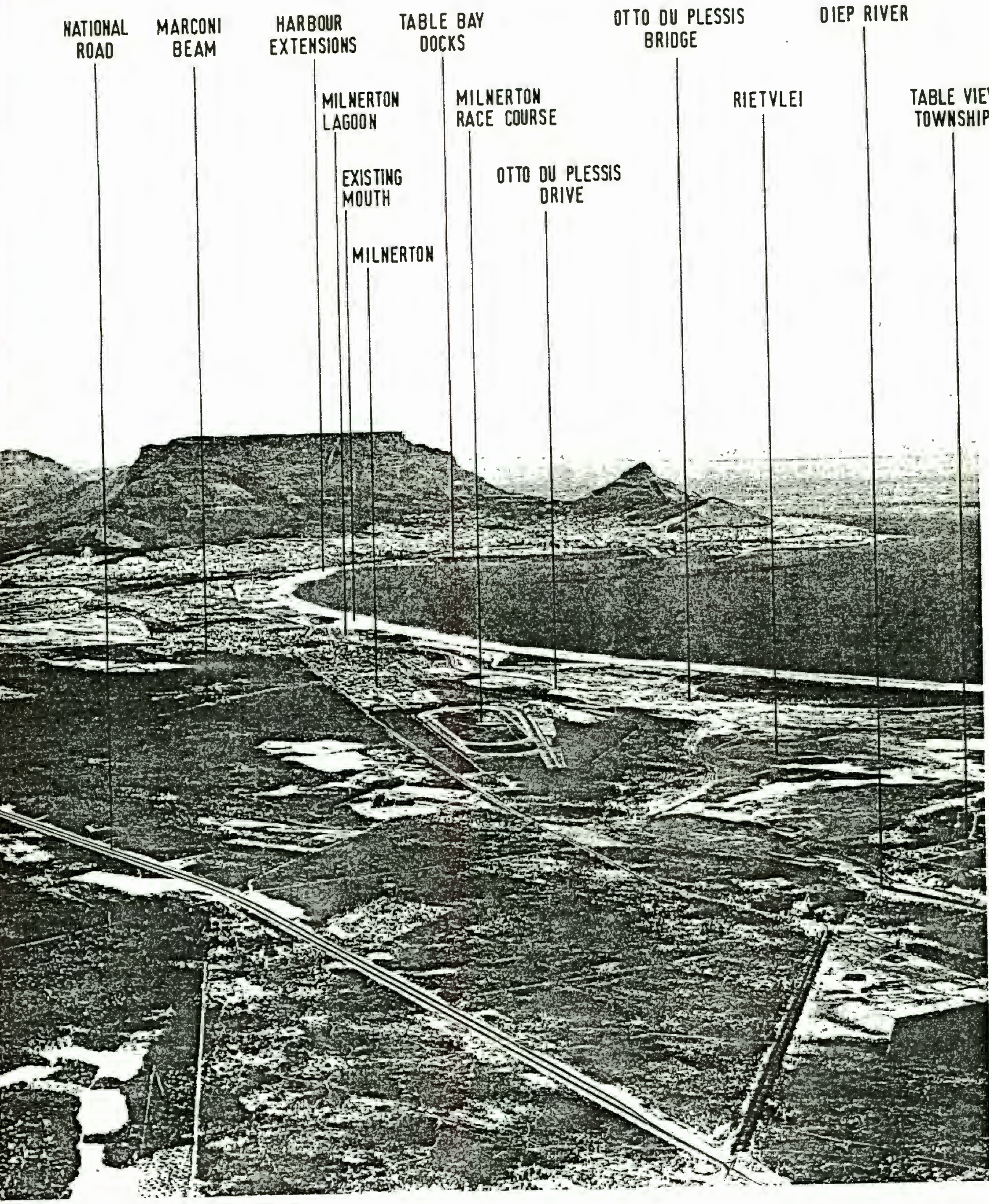
Delphi Briefing Document - Case Study 3 (Rietvlei)

(Excerpted from Stauth, 1983b, pp198-212)

ENVIRONMENTAL EVALUATION PROPOSAL

RIETVLEI-MILNERTON LAGOON SYSTEM

TABLE OF CONTENTS



RIETVLEI LOCALITY

SOUTH WESTWARD OBLIQUE

DESCRIPTION OF THE STUDY

1. Two alternative land uses have been proposed for the Rietvlei-Milnerton lagoon area: (a) an inland marina development, and (b) a proclaimed nature area.

2. The object of this study is to determine which use will bring the greatest net benefits to society.

3. Two panels are being assembled to evaluate the alternatives. An impact identification panel (composed of experts, concerned parties, and members of the impact weighting panel) will identify and define the impacts which could result from each proposal. These impacts will then be investigated by appropriate experts, and estimates of their magnitude will be compiled in an environmental impact report. An impact weighting panel, composed of individuals who are "generalists" and considered to be "neutral" or unbiased, will review this report and appraise the social significance of the impacts.

4. The Delphi technique will be used as the assessment procedure by both panels. Delphi is a forecasting and evaluation technique for obtaining subjective but informed judgments when there is a lack of objective, quantifiable data. The technique enhances information exchange and promotes consensus through anonymous debate, controlled feedback, and statistical group response. Individuals compare their own assessments with those made by the group as a whole, and are given the opportunity to modify their response or communicate new information which may modify the group response. After two or three iterations, group thinking generally evolves toward a consensus.

5. Members of the impact identification panel will be asked to read the present document and then make a short visit to the site for orientation (transportation to be arranged at a convenient date).

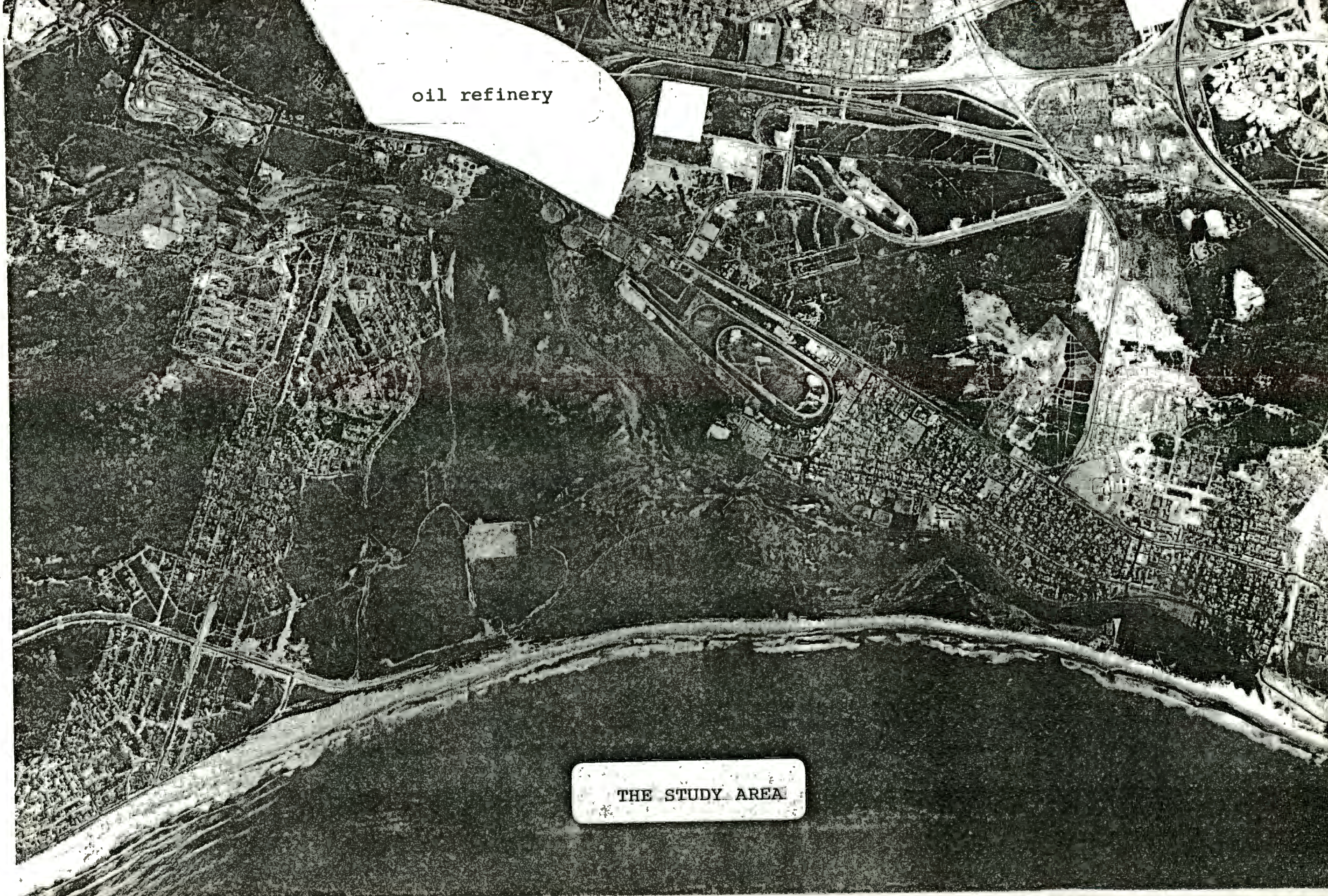
   Panel members are to consider the possible impacts (both positive and negative) which could result from each land-use proposal, list these impacts on the "Impact Identification Forms" provided, and return these forms at an early date to the coordinator in the self-addressed envelope provided.

   The coordinator will compile and summarize the individual lists of impacts for distribution to the panel members, who will then be asked to (a) approve or disapprove of the wording of the impact statements, and (b) suggest new wording or add new impact statements, giving any reasons they care to offer.

   The process will be repeated until all impacts have been identified and there is general agreement as to how they should be defined.

6. Investigations by a team of experts will be conducted to assess the magnitude of the impacts and obtain other information needed by the impact weighting panel.

7. Members of the impact weighting panel will be asked to read the environmental impact report and then attend a half-day meeting (date and venue yet to be determined, but probably in February or March at UCT). Impacts will first be ranked, and then judgments will be made as to their relative significance. The evaluation procedure will consist of several iterations of impact ranking and weighting, and feedback between iterations will include (anonymous) individual comments and computer-generated histograms of group response. The object will be to compare the relative values of these impacts to the financial costs and benefits of the projects, and then calculate "contingency prices" for selected impacts which can be evaluated for reasonableness.


oil refinery
THE STUDY AREA

DESCRIPTION OF THE STUDY AREA

Name: Rietvlei-Milnerton lagoon

Location: Approximately 10 km north-east of Cape Town, between Milnerton and Table View.

Area and Boundaries: The vlei is a roughly triangular basin of approximately 500 ha, into which the Diep River flows. The vlei area extends from the Blaauwberg Bridge to the Otto du Plessis Bridge. The lagoon is an estuarine system which extends some 4 km from the Otto du Plessis Bridge to the sea. Otto du Plessis drive runs along the eastern boundary of the lagoon and then follows the western boundary of the vlei. The boundaries of the proposed nature area are based largely on estimates of the 50-year floodline.

Adjoining Areas: The vlei-lagoon area is bounded by residential and industrial developments on the north and east, and a narrow strip of largely undeveloped land on the west fronting Table Bay. The Milnerton golf course is situated on the west side of the lagoon, and some of the adjacent dunes support stands of unspoilt coastal vegetation. Extensions 7, 8, and 13 of Table View Township lie on the northern boundary of the vlei. While there are no roads or developments immediately adjoining the eastern boundary, there are several notable developments near the eastern side of the vlei: the Milnerton Sewage Disposal Works, sport fields of the Milnerton Sports Club, Milnerton Race Course (Ascot), Fedmis fertilizer factory, and the Caltex petroleum refinery. To the south are the Salt River Power Station and Ysterplaat Air Station.

Land Ownership: Milnerton Estates owns 69% of the area which would be included in the nature area, and S A Transport Services owns 31%.

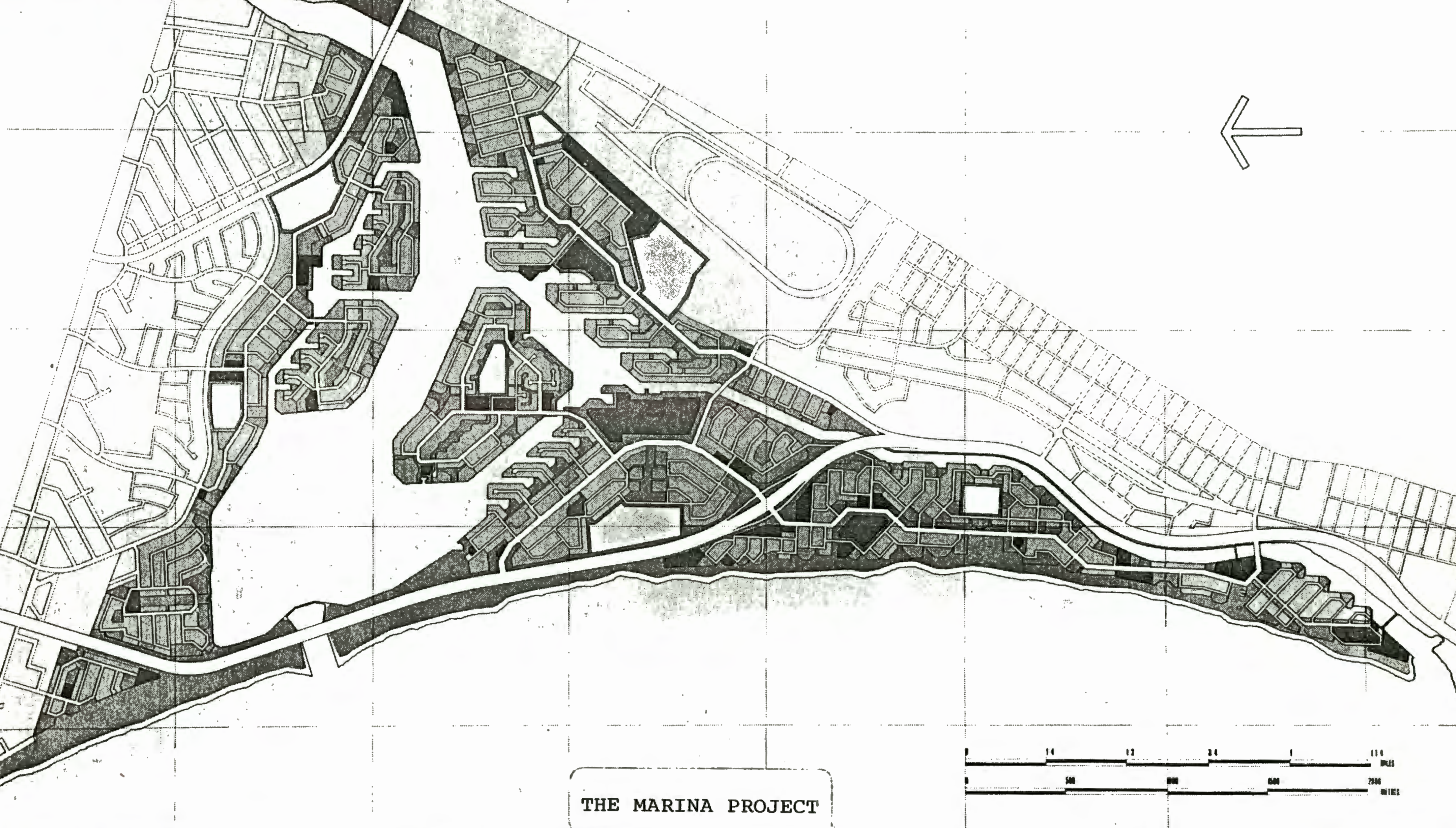
The Lagoon and its Present Uses: The lagoon is a fairly shallow and narrow system, with a depth ranging from 0,5 to 2,0 metres and an average width of approximately 100 metres (it is 150 metres at its widest point). It is a potentially rich feeding ground and nursery area for fish, but the mouth is generally closed and so marine species have infrequent access to the area. The estuarine fauna is rather impoverished, but the lagoon is frequented by water birds. Local residents use the water body for canoeing and bait gathering.

The Vlei and its Present Uses: The vlei is about 2 km wide and 1,5 km long, and the average elevation above Mean Sea Level is less than 2 metres. Vegetation is sparse and lacking in species richness, but the existing vegetation is highly productive. Alien vegetation dominates the bordering scrubland and grass belt. The fauna is not particularly notable except for the great numbers of water birds, which tend to concentrate in the north-east sector. Several species of migratory waterfowl frequent the area, and Rietvlei is considered to be one of the richest water bird areas in the western Cape.

The Vlei presently supports limited cattle and sheep grazing but is not considered suitable for agricultural use. The area is also not considered suitable for conventional residential or industrial developments due to foundation problems and flooding hazards. There is no mineral potential.

There is a permanent deep water area (up to 16 metres) called Flamingo Vlei in the north-western sector which is used by the Milnerton Aquatic Club for fishing, sailing, power boating, and water skiing. The low-lying area north of Flamingo Vlei is used by trail bikers. The Cape Radio Flyers Club has facilities for flying radio-controlled model airplanes on the western side of the vlei. Visitors are allowed to this part of the vlei when flying is in progress, but in general public access to the vlei is restricted.

General Considerations: Rietvlei-Milnerton lagoon is at the northern edge of a rapidly expanding metropolitan area in which there are few natural wetland areas and few suitable sites for marina-type developments. This system appears to be uniquely suited for both uses. Wetland areas have recreation, conservation, and education value, and marina developments provide attractive residential areas which may stimulate local and regional economic development.



SINGLE RESIDENTIAL
GROUP HOUSING
GENERAL RESIDENTIAL
CIVIC AND COMMERCIAL
OPEN SPACE
SCHOOLS

MASTER PLAN · SCHEME A

MED

DESCRIPTION OF THE MARINA PROJECT

The marina development has been planned as a water orientated community of over 30,000 people, with a full range of housing types. There will be inland sailing areas, but no water access to the sea. Flood and water level control are key elements in the plan, to ensure that a safe and high quality environment will always be maintained.

The project will have a powerful impact on the structure and nature of Milnerton and could provide the future focal point for the local region. Phased development will take place over a 47-year period, with a projected 200 residential erven sold per year from year 16. Net density (based on land area, excluding waterways) is 52 persons per ha.

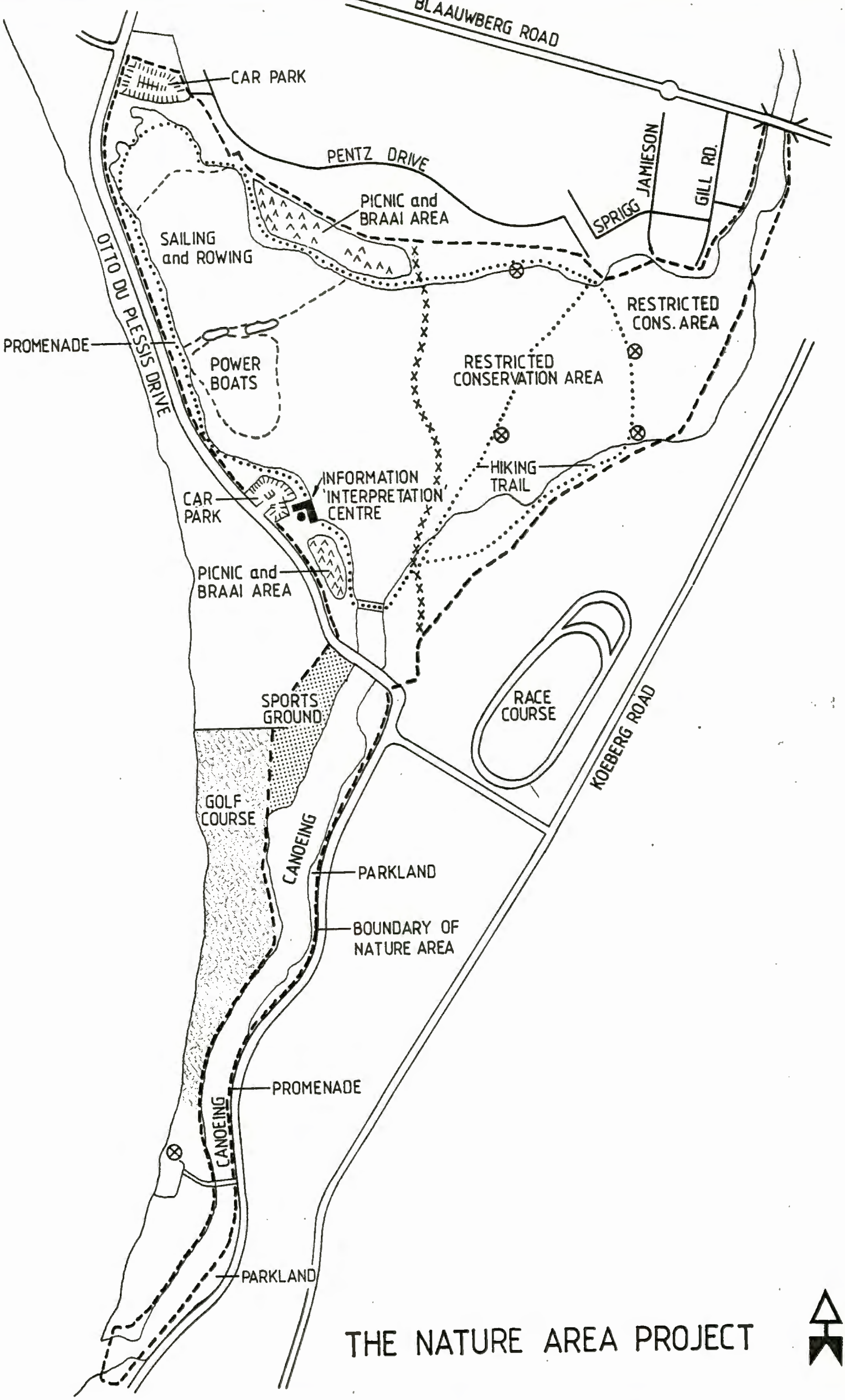
The principal feature of the scheme is a 243 ha lake which will be dredged out of the vlei, and community lay-out is designed to provide maximum water-fronted development. The community will have a wide variety of housing types: there will be approximately 3500 single residential units (four occupants per unit), 2600 group housing units (3,5 occupants per unit), and 3000 general residential units (2,5 occupants per unit). Architectural and planning control will maintain overall coherence.

Commercial areas are distributed throughout four major zones and cover about 16,5 ha. Plans also include six primary and three high schools (on 46,2 ha), a series of green belt systems linking homes to shops, schools, and recreational facilities (totaling 65,9 ha), and facilities for the local authority, police, and post office (8,46 ha).

The Milnerton municipality will incur certain costs in providing new community services and then administrating and maintaining these services; however, it is anticipated that these costs will be largely offset by increased revenue from rates due to a broader tax base and higher property values.

Development actions include dredging of the lagoon, excavation and filling of the vlei, bank protection, a flood diversion weir, an estuary weir, a lake water augmentation system, a water quality control programme, demolition of existing structures, removal of certain amenities (e.g., the golf course), landscaping improvements, and construction of new and improved roads and bridges. Additional township services include stormwater drainage to the vlei and lagoon by means of relatively small stormwater pipes or culverts, a waterborne sewerage reticulation system, water mains to be extended from the existing reticulation (no additional storage capacity required), underground electricity, telephone, and television cables, and irrigation systems for green belt areas.

The large areas of water and open space will provide valuable recreational opportunities and a pleasing atmosphere for residents. The community will be a unique and attractive asset in the Cape peninsula region: inland sailing and power boating in the Cape is tremendously curtailed by the lack of suitable waterways, and this development would provide a pleasant and convenient outlet for water-related activities in a sea-side setting.



THE NATURE AREA PROJECT

DESCRIPTION OF THE NATURE AREA PROJECT

Although a final management plan has not yet been developed for the nature area, a general policy and some provisional plans have been formulated and are described in what follows.

The nature area will be managed for multiple use within the carrying capacity of the system. The goal will be to provide recreation, conservation, and education benefits to residents of the metropolitan region on a sustained-yield basis. In order to accomplish this goal, the area will be zoned and use limitations for each activity will be imposed as required.

The Rietvlei area is on a major transport route and is conveniently situated for more than one million people from all socio-economic levels. Although recreational capacity has not yet been determined, it is anticipated that the area can accomodate upwards of 100,000 visitors per annum. Staff will include one officer in charge, two assistants, and ten labourers.

It is anticipated that all presently existing uses and activities will be allowed to continue - these include power boating, water skiing, sail boating, sail surfing, canoeing, fishing, hiking, bird watching, trail bike riding, model airplane flying, and picnicking. Many of these activities will be enhanced by the provision of new public amenities, such as bird-watching hides, ±6 km of hiking trails, interpretative facilities, landscaped picnic sites, fish stocking programmes, eradication of alien vegetation, and wildlife management programmes.

The eastern side of the vlei will be managed for conservation, the principal resource being the rich bird habitat. Access to certain portions of this area will be restricted, but a large region will be ringed by a self-guided, interpretative trail. The trail head will be located at the main parking area north of the Otto du Plessis Bridge on the west side of the vlei. An interpretation centre located at this site will contain a museum exhibiting the local flora and fauna, an audio-visual room featuring slides and movies of the area, and a room containing a variety of displays describing the history and features of the area. This facility, along with the hiking trail through a natural ecosystem, will be of special interest to the more than 400 schools and colleges in close proximity. Also of educational interest will be a research facility managed by the Cape Department of Nature and Environmental Conservation.

The western side of the vlei (which includes the deep water "Flamingo Vlei" area) and the lagoon will be managed for recreation. Water sports will be featured, but the area will provide a venue for many other outdoor activities. The banks of the lagoon will be maintained as parkland and will feature picnic areas. The western vlei will accommodate trail bike riding, model airplane flying, braaiing, and picnicking.

The nature area will constitute one of the largest general open-space areas in the metropolitan region, offering a large and growing population convenient access to an area featuring several desirable natural features: vlei, lake, lagoon, dunes, beach, and a view of Table Mountain across the bay.

APPENDIX

COMPONENT ADVICE NOTES

Many of the physical, biological, and socioeconomic components of the existing system could be substantially modified by one or both of the proposals. These notes briefly describe the principal functions and potential uses of key components in the coastal system which (1) may be considered socially significant, and (2) could be impacted by one of the management plans. The object is to provide assessors with a check-list or guide which will assist in the identification of potentially significant impacts.

Physical Components

Flood plain

Lakes

Islands

Mudflats

Lagoon

Lagoon Mouth

Freshwater

Saltwater

Tidal Exchange

Longshore Currents and Waves

Beaches and Dunes

Marine Sediments

Freshwater Sediments

Nutrients

Biological Components

Terrestrial Vegetation

Marginal Vegetation

Marshes

Aquatic Macrophytes and Plankton

Invertebrates

Vertebrates

Socioeconomic Components

Historic Sites

Golf Course

Roads

Commercial Enterprises

Houses and Household Sewage

Industries and Industrial Effluent

Tourists and Recreationists

Power Boats

Holistic Component

Vlei-lagoon System as Integrated Component

PHYSICAL COMPONENTS

Flood Plain

The flood plain serves as a flood absorption dam, mitigating the flood hazard to surrounding communities, and stores and regulates normal flows of water through the system, thus maintaining balanced water levels in wetland areas and the lagoon. The flood plain can also have general, open-space recreational uses, and may be considered an important aesthetic landscape feature.

Lakes

Flamingo Vlei provides a semi-exclusive recreational area featuring water-related activities, such as fishing, swimming, sailing, power boating, and water skiing. The lakes have aesthetic appeal and provide variety in the landscape.

Islands

Small islands found in the system (depending on water levels) offer special refuge and protection to waterfowl and other wildlife. They also add variety to the landscape.

Mudflats

Regularly inundated mudflats provide rich feeding areas for birds (when water conditions are low) and for fish (when water conditions are high). These areas also constitute nutrient sinks and so play a role in the bio-geochemical cycling of nutrients.

Lagoon

The bed of the lagoon provides habitat for bottom-dwelling organisms. Nutrients are cycled through nitrate and sulphate reduction in anaerobic muds. Submerged plants produce oxygen and food for fauna, including bait organisms and fish. Canoeists and wind-surfers use the water body for uncrowded recreation. The banks of the lagoon provide shade and shelter for fish, picnic sites and walking areas, and open, aesthetically-pleasing surroundings for residents and passers-by.

Lagoon Mouth

The mouth of the estuarine system permits an exchange of physical, chemical, and biological elements between the marine and freshwater environments. The mouth is the point of ingress/egress for:

(a) sediments (determines shape of mouth and channels, location of reedbeds and saltmarshes);

(b) chemicals and water (needed for maintaining critical habitat parameters);

(c) nutrients (needed for biological productivity); and

(d) marine fish and other biota (provides access to feeding and nursery grounds).

Freshwater

River water entering the system maintains critical habitats for aquatic vegetation, waterfowl, wildlife, and fishery resources. When the mouth is open, freshwater flow transports nutrients to coastal waters which can increase marine productivity. Riverflow also plays a role in the biogeochemical cycling of nutrients, and the processing and assimilation of waste products (sewage, agricultural runoff, pesticides, solid waste, trace metals, and heat). Finally, freshwater is an essential element in several recreational activities (swimming, fishing, boating, etc.) and enhances the aesthetic quality of the area both directly (in its visual appeal) and through maintaining the health of the ecosystem.

Saltwater

Saltwater is needed to maintain habitat conditions for estuarine species and temporary marine residents. Saltwater also induces flocculation and precipitation of sediments and nutrients.

Tidal Exchange

Tidal action brings about the exchange of nutrients, sediments, plankton, uprooted macrophytes, and fish between the marine and river elements. The tide's scouring and filling action affects the position and shape of the lagoon's mouth, as well as the placement of sand bars and beaches around the mouth. Tidal flows also stimulate growth of saltmarsh vegetation, and expose mudflats and sand flats for bird feeding and bait collecting.

Longshore Currents and Waves

Currents and waves are erosive mechanisms which alter coastal features (including the position and shape of a river mouth), and transport mechanisms for marine sediments (which determine the distribution and rate of deposition or removal of coastal sediments).

Beaches and Dunes

Beaches and dunes constitute a dynamic interface zone between the land and the sea. They act as a buffer against wave erosion, can affect the position and type of mouth of a coastal lagoon or river system, and are important aesthetic and recreational features of the coastal landscape.

Marine Sediments

Marine sediments provide materials for beach and dune formations, sand flats, and sand bars which block river mouths and provide habitat for some organisms.

Freshwater Sediments

Fine sediments can smother bottom-dwelling organisms, fill the river channel, and close the mouth. Mud deposits promote the spread of reedbeds and restrict water-related recreation.

Nutrients

Increases in nutrient levels can increase biological productivity, which sometimes leads to algae blooms and eutrophic conditions. Nutrient levels affect the turnover of biomass and species composition/diversity.

BIOLOGICAL COMPONENTS

Biological components add interest and beauty to the landscape, and perform ecological functions which benefit man. Plants convert radiant energy to chemical energy and take up nutrients to form the base of the food chain. Larger plants provide special habitat for animals - critical habitats include areas for feeding, resting, hiding, breeding, and nesting. Animals are sources of secondary productivity which form higher links in the food chain. Each species exploits a different niche, and this leads to a high level of diversity and a complex system of dependencies, some of which support, or are beneficial to, man.

Terrestrial Vegetation

Trees, shrubs, and grasses bind the soil and facilitate percolation of rain water, thus slowing erosion and recharging groundwater stores. Indigenous vegetation has aesthetic value and is of special scientific interest, particularly rare, endangered, and endemic species. Invasive alien vegetation can displace the indigenous species and greatly transform the landscape.

Marginal Vegetation

Plants which favour the water's edge provide shade and shelter for animal life and help stabilize banks and shoreline. This vegetation also takes up nutrients, traps silt, and builds up land and muddy areas.

Marshes

Marshes produce detritus, the decaying plant material which is an important food source for many organisms, including filter and deposit feeders, estuarine fishes, and juvenile marine fishes. Marshes also serve to:

(a) buffer other components from floods;

(b) store and regulate the release of water;

(c) store and cycle nutrients;

(d) trap sediments to prevent siltation downstream;

(e) clean air and water;

(f) provide critical habitat (breeding, feeding, and nursery areas for many faunal elements); and

(g) provide a unique recreational resource for the local community.

Aquatic Macrophytes and Plankton

Larger water plants provide shelter and oxygenated water for fauna and are a source of detritus. Phytoplankton are primary producers and, along with zooplankton, are sources of food for aquatic invertebrates and vertebrates.

Invertebrates

Some invertebrates are scavengers and so perform an organic waste disposal function. Burrowing animals increase the productivity of a system through sediment turnover, aeration, and nutrient enrichment. Some of these animals are desirable bait organisms. Invertebrates also constitute links in the food chain and so serve to support populations of higher animals.

Vertebrates

Fishes, birds, and mammals are among the more conspicuous and interesting features in the landscape. They serve ecological, aesthetic, recreational, and educational functions. Fishes may be of commercial value, and birds - particularly migratory waterfowl - may be of national and even international interest (South Africa is a signatory to the Ramsar Convention which is intended to protect important wetlands and their biota).

SOCIOECONOMIC COMPONENTS

Historical Sites

Although there are no designated historic sites in the system, the area is a reminder of past conditions and uses, and some features of historical interest may still be identified. Many historical maps, diaries, reports, and other documents refer to various features of the vlei, and comparisons of historical accounts with present conditions is of scientific and general interest.

Golf Course

A principal recreational feature is the golf course, situated between the lagoon and the sea, with a panoramic view of Table Mountain.

Roads

Existing roads separate the vlei, lagoon, and dune/beach systems, and traffic may reduce the aesthetic and recreational value of the area. New roads would facilitate the transport of goods and people, but would also remove more habitat and form new barriers to the exchange of physical and biotic elements.

Commercial Enterprises

New businesses in the area would provide jobs and be a source of goods and services for residents and visitors; however, commercial activities would have secondary impacts which may be undesirable (e.g., physical congestion, changes in social networks, increased demand for natural resources, etc.).

Houses and Household Sewage

New houses in the area could enhance the community, but they would also eradicate natural vegetation, destroy wildlife habitat, spoil scenic features and produce waste products. Household sewage can increase nutrient levels and pathogens in water bodies, and can lead to aesthetically displeasing conditions.

Industries and Industrial Effluent

Existing industries in the area are sources of air pollution, represent potential sources of water pollution, and are visually obtrusive. This may reduce the aesthetic and recreational value of the area and endanger health. New industries attracted to the area would provide jobs and produce useful products, but they would generate more waste products and could further degrade the scenic quality of the area. Industrial effluent damages terrestrial and aquatic biota, reduces species diversity, is aesthetically displeasing, and can be injurious to human health.

Tourists and Recreationists

Tourists and recreationists attracted to the area would provide job opportunities for the local population and revenue for local businesses; however, increased demand for services from the natural and social environments could lead to despoilation and congestion.

Power Boats

Boats are vehicles for desirable recreational opportunities; however, they can be noisy, sometimes discharge pollutants into water, and generate wave action which erodes banks.

HOLISTIC COMPONENT

The vlei-lagoon and adjacent coastal elements can be regarded as a single, integrated system. Some of the special functions and uses of integrated coastal components are described in general terms as follows.

Being part of the natural interface between river, land, and sea, such systems serve to maintain a dynamic equilibrium among coastal elements at low cost to man, and play a role in biogeochemical cycling. These systems are generally noted for their high species diversity, richness, and biomass. They can provide critical habitat for rare and endangered species, areas for scientific research, and sites for specialized recreational activity. They may also be regarded as aesthetically unique areas, which present a great variety of elements to the discerning eye. Finally, such systems may have significant but as yet undiscovered functions and potential uses.

ILLUSTRATIVE MATERIAL

APPENDIX DD

Initial Listing of Impacts - Case Study 3 (Rietvlei)

(Excerpted from Stauth, 1983b, pp.294-301)

UNIVERSITY OF CAPE TOWN

(WITH WHICH IS INCORPORATED THE SOUTH AFRICAN COLLEGE)

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SOUTH AFRICA

SCHOOL OF ENVIRONMENTAL STUDIES

20th December, 1982.

ENVIRONMENTAL EVALUATION STUDY : RIETVLEI-MILNERTON LAGOON SYSTEM

Dear

Please find enclosed a synthesis of comments received to date identifying the impacts which could result from both the marina project and the nature area project. Regardless of whether you have returned your Impact Identification Forms, I would appreciate your comments on the impacts as defined in the accompanying lists. It is important that panel members are in general agreement as to the way impacts are defined.

The following points should be noted:

1. Impact statements which were very similar to others or which could be considered as a sub-category of impact have been aggregated and stated in a more general form. This was done to avoid overlapping and to reduce the number of impact statements to a more manageable level.

2. Impact statements have been phrased to indicate how individuals and society will be affected (i.e. attention is drawn to the way impacts on the biophysical environment will affect the socioeconomic environment). This was done because the Delphi meeting will be primarily concerned with determining how the proposed projects will affect social well-being.

3. Since benefits associated with one project can also be regarded as foregone opportunities - and therefore costs - of adopting the other project, it is possible to phrase all impacts in terms of costs. (For example, adoption of the nature area project would mean foregoing the opportunity which the marina project offers of creating employment and stimulating business, and so this beneficial impact of the marina project - "generating new jobs and income" - can be counted as a cost of the nature area project - "lost opportunity for generating new jobs and income".) All impacts have been stated as costs in order to produce a list of costs only for each project. This will greatly facilitate analysis in the forthcoming Delphi meeting.

Before conducting investigations into the magnitude of these impacts, we wish to ensure that panel members are generally satisfied with the clarity and completeness of the impact statements. You are therefore requested to read the impacts and make any comments (either directly on the sheets or on a separate piece of paper) and post them to me in the addressed envelope provided. Comments are solicited on the following:

1. Are you satisfied with the impact statements as defined? If not, please suggest alternative impact statement definitions. (It is not necessary at this stage to express opinions as to the significance of the impacts.)

2. Do any of the impacts overlap or interact to a significant degree? If so, please state which ones should be combined and suggest how the new impact statement should be phrased.

3. Are you satisfied that the list of impacts is complete? If not, please add new impact statements to the list.

Thank you for your continued cooperation. It would be greatly appreciated if you could reply within a few days of receiving this letter so that a revised list of impacts can be prepared and reviewed, and the potential impacts investigated, before the Delphi meeting in February/March.

Sincerely yours,

Roy Stauth
Senior Research Officer.

RS/hmk

UNPRICED COSTS OF THE NATURE AREA PROJECT

1. NOISE POLLUTION

Certain recreation activities may create a disturbing level of noise:

a) power boats on Flamingo Vlei may be heard from Table View township and parts of the vlei;

b) trail bike riding and model aircraft flying may be heard from many parts of the vlei, as well as from adjoining dunes, beaches, and residential areas.

2. UNDESIRABLE BIOLOGICAL ELEMENTS

Certain species could proliferate and become pests in the local area:

a) snakes could infest adjoining gardens and houses;

b) mosquitoes could breed in the water and annoy local residents;

c) birds using the vlei may become a nuisance when roosting in residential areas.

3. DANGER TO PUBLIC SAFETY

The large, open area could harbour dangerous persons, and the absence of flood control measures means some homes would be threatened with flooding:

a) vagrants, muggers, and rapists could frequent the area and victimize residents and visitors;

b) periodic floods could result in property damage or loss of life.

4. LOST JOBS AND INCOME

Failure to implement the marina project would mean foregoing opportunities to create more jobs and generate more income in the private and public sectors:

a) employment opportunities during the 47-year construction period of the marina project would be lost;

b) building contractors and suppliers would lose potential business;

c) the stimulative (or multiplier) effect to local business and industry would be foregone;

d) the small craft industry would lose an opportunity to expand its market;

e) the Milnerton municipality would forego increased revenue from rates which could be derived from the marina project.

5. LOST OPPORTUNITY TO IMPROVE CHARACTER AND AMENITY VALUE OF MILNERTON AND GREATER CAPE TOWN

Failure to implement the marina project would mean foregoing opportunities to improve certain conditions in the local and regional urban environments:

a) the opportunity to give Milnerton a "focus" which could generate strong community pride would be lost;

b) the opportunity to offer a unique waterfront housing development close to the centre of Cape Town would be lost;

c) the opportunity to offer expanded watersport facilities (associated with the 243 ha lake) to the metropolitan population would be lost;

d) the opportunity to create an attractive built environment (which may be more aesthetically pleasing to the average person than the flat, open, relatively featureless natural environment) would be lost;

e) the opportunity to reduce pressure for housing in other parts of metropolitan Cape Town would be lost.

UNPRICED COSTS OF THE MARINA PROJECT

1. REDUCED LANDSCAPE DIVERSITY AND AESTHETIC QUALITY

   The loss of open space, natural features, and biological elements will diminish the variety and beauty of the present landscape:

   a) the loss of open space and natural features in a predominantly built-up area will make the landscape more uniform and monotonous;
   b) increases in litter, sewage, and other wastes may have aesthetic impacts within the project area and in adjacent areas (both land and sea);
   c) water quality may deteriorate due to increased pollution, nutrient-enrichment (from sewage and run-off), siltation, hydrogen sulphide production and algal decay (from stagnation, stratification, and deoxygenation);
   d) the destruction of biological habitat and sources of primary production would reduce the numbers and therefore the visual impact of some populations, particularly highly-valued species of water birds.

2. GENETIC LOSSES

   Potentially valuable genetic information could be lost if gene pools are not maintained at safe levels:

   a) the loss of highly productive wetlands will reduce critical habitat available to certain rare and endangered species;
   b) another link in the system of wetlands used by migratory species of water birds will be eliminated, and this could endanger the viability of some populations;
   c) reductions in local plant and animal populations due to habitat destruction and disruption of ecological processes may threaten general losses of genetic diversity and co-evolutionary developments of scientific interest.

3. LOST OPTIONS

   Potentially valuable resource options may be lost when the natural environment is substantially altered:

   a) certain components of the biophysical environment may perform important but still undiscovered functions benefiting the socioeconomic environment;
   b) the destruction of natural resources precludes exercising future options for resource utilization which may arise as a result of new discoveries.

4. LOST LEGACY

Part of society's natural and cultural heritage would be irretrievably lost:

a) the loss of another natural area, and knowledge that fewer natural places now exist, would disturb some people;
b) an area of historical interest would be lost, including historic structures (e.g., the wooden bridge) and natural features (e.g., the vlei, which featured in many early maps and diaries).

5. LOST EDUCATIONAL AND RESEARCH FACILITY

The opportunity to provide over 400 schools and colleges, as well as other educational and research organizations, with a "natural classroom and laboratory" would be lost:

a) students in the metropolitan area would lose an opportunity to get direct lessons in nature study in an interesting transitional zone where several ecosystems meet (e.g., riverine, freshwater wetland, estuarine, dune, marine, terrestrial, urban, etc.);
b) an opportunity to promote greater awareness of nature in an urban population through direct contact with a natural system would be lost;
c) a natural laboratory for ecosystem research, including basic ecosystem functioning, monitoring of pollution impacts on natural ecosystems, and rehabilitation of damaged ecosystems, would be lost.

6. LOST RECREATION AND TOURISM BENEFITS

Opportunities for several outdoor recreational pursuits will be diminished, and the area's appeal to tourists may be impaired:

a) the loss of space for outdoor recreational activities in an urban setting may increase sociological pressures and decrease the quality of life - reducing the area available for hiking, bird watching, horse riding, trail bike riding, flying model aircraft, etc. would deprive metropolitan Cape Town's large and rapidly growing population of adequate recreational opportunities;
b) if water quality in the dredged lake and lagoon system deteriorates (due to difficulties in maintaining constant levels, adequate depth, mixing, purity, etc.), the recreational utility of the area's water resources could be lost;
c) tourists may feel there is less of interest to see in the area (if the variety of birds is reduced, and the interesting juxtaposition of

natural elements - e.g., vlei, lagoon, dunes, beach, and sea - is lost, which also provides enhanced views of Table Mountain), and tourism revenues in the Cape Peninsula may decline.

7. INCREASED RISK OF PROPERTY DAMAGE AND LOSS OF LIFE FROM FLOODING

Flood controls to compensate for the loss of the floodplain may prove inadequate:

a) homes in the surrounding area, as well as marina homes, may be subject to flood damage;
b) extreme floods would threaten residents in the flood zone with injury or loss of life.

8. INCREASED RISK TO HEALTH, PROPERTY, AND WELL-BEING FROM AIR POLLUTION

Air quality may deteriorate if more of the area's natural vegetation (which serves as a "green lung") is displaced by the built environment;

a) the loss of vegetation in an area subjected to significant levels of air pollution may increase health hazards;
b) higher pollution levels could damage property and increase maintenance costs;
c) increased awareness of air pollution through visual and olfactory perception could reduce the amenity value of the area;
d) air pollution impacts could lower property values in the area.

9. CONGESTION EFFECTS

The influx of new residents and visitors to the area could impose a significant burden on present residents and users of the area:

a) increased noise pollution from boats on the new lake may disturb local residents;
b) greater traffic congestion in the local area may increase travel time and psychological costs for residents, or lead to higher rates and taxes for improved roadworks;
c) some residents could have views blocked or spoiled;
d) residents who were attracted to the area by the present conditions and atmosphere might regret that the character of the area has been irreversibly altered;
e) increased crowding of water areas, beaches, and dunes will degrade certain aspects of these features, or inhibit some uses;

f) overuse of the area's amenities may necessitate bothersome regulations and expensive control measures.

10. INCREASED SOCIAL TENSION

The marina project could create greater social pressures:

a) existing social and racial amimosities could be exacerbated by resentment that a general amenity will be lost and only a few priviliged families will significantly benefit from the project;

b) conservationists could resent the loss of potential jobs and opportunities to promote their cause;

c) development of a high quality residential scheme could result in pressure to restrict further industrial development in the general area;

d) the long construction period could disrupt the Milnerton area for much of the 47 years which will be required to complete the project;

e) there is a possibility that the project may not be satisfactorily completed or maintained due to changes in market conditions, or a lack of resources or skills on the part of the developer or the municipality.

ILLUSTRATIVE MATERIAL

APPENDIX EE

Revised Listing of Impacts - Case Study 3 (Rietvlei)

(Excerpted from Stauth, 1983b, pp.302-310)

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(WITH WHICH IS INCORPORATED THE SOUTH AFRICAN COLLEGE)

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SCHOOL OF ENVIRONMENTAL STUDIES

3rd February, 1983.

ENVIRONMENTAL EVALUATION STUDY : RIETVLEI-MILNERTON LAGOON SYSTEM

Dear

Please find enclosed a revised list of impacts for the nature area project and the marina project. If you are satisfied with the way all unpriced costs have been defined, simply retain this document and bring it with you to the Delphi meeting which will be held in March. If you are not satisfied with any of the definitions, please send me your comments and I will revise this document again.

I have tried to accommodate all the comments which have been received, but for various reasons some may have been omitted. For example, monetary impacts and impacts which are common to both projects have been excluded. Please note that the sub-categories of each impact are intended as explanatory statements, and these may sometimes appear to overlap.

The half-day Delphi meeting is now planned for sometime in March at U.C.T. You will be notified of the date, time and venue at a later date.

Thank you for your continued interest and cooperation.

Sincerely yours,

Roy Stauth
Senior Research Officer.

RS/hmk

UNPRICED COSTS OF THE NATURE AREA PROJECT

A. NOISE POLLUTION

Certain recreation activities may create a disturbing level of noise:

a) power boats on Flamingo Vlei may be heard from Table View Township and parts of the vlei;

b) trail bike riding, beach-buggies and model aircraft flying may be heard from many parts of the vlei, as well as from adjoining dunes, beaches, and residential areas.

B. UNDESIRABLE BIOLOGICAL ELEMENTS

Certain species could proliferate and become pests in the local area:

a) snakes could infest adjoining gardens and houses;

b) mosquitoes could breed in the water and annoy local residents;

c) birds using the vlei may become a nuisance when roosting in residential areas, and may constitute a danger to low-flying aircraft;

d) stray animals could occupy the area.

C. GREATER DANGER TO PUBLIC SAFETY

The large, open area could harbour undesirable and dangerous persons.

a) Vagrants and loiterers could frequent the area to the annoyance of residents and visitors;

b) muggers and rapists might utilize secluded areas to victimize residents and visitors;

c) neighbouring residential areas could experience a general deterioration in social and environmental quality.

D. GREATER DANGER OF FLOODING AND FIRES

Structures in the area would be threatened by flood and fire.

a) The absence of flood control measures means that periodic floods could result in property damage and loss of life;

b) the large number of recreational visitors could result in a high incidence of fires which would constitute a threat to lives and property in the area.

E. LOST JOBS AND INCOME

Implementing the nature area project would mean foregoing opportunities to create more jobs and generate more income in the private and public sectors:

a) employment opportunities during the 47-year construction period of the marina project would be lost;
b) building contractors and suppliers would lose potential business;
c) the stimulative effect to local business and industry (from adding 30 000 persons to the population, plus visitors and tourists) would be foregone;
d) the Milnerton Municipality would forego increased revenue from rates which could be derived from the marina project;
e) an opportunity to increase property values in the area would be foregone.

F. LOST OPPORTUNITY TO IMPROVE THE BUILT ENVIRONMENT

Failure to implement the marina project would mean foregoing opportunities to improve the character and amenity value of Milnerton and Greater Cape Town:

a) the opportunity to give Milnerton a prestigious development as a "focus" which could generate strong community pride would be lost;
b) the opportunity to offer a waterfront housing development with pleasing water-vistas close to the centre of Cape Town would be lost;
c) the opportunity to offer expanded watersport and other recreational facilities (associated with the 243 ha lake) to the metropolitan population would be lost;
d) the opportunity to promote tourism (with sailing regattas, boating festivals, and other special, water-related events) would be lost;
e) the opportunity to create an attractive built environment (which may be more aesthetically pleasing to the average person than the flat, open, relatively featureless natural environment) would be lost;
f) the opportunity to reduce pressure for housing in other parts of metropolitan Cape Town would be lost.

G. GREATER COSTS FOR SERVICES AND TRANSPORT

Implementing the nature area project would mean higher per capita costs for basic services and transportation:

a) the cost of basic services per dwelling unit could be reduced by concentrating the population in a smaller area (so that the infrastructure need not be "stretched" so much);

b) fuel consumption could be reduced if residents did not have to drive so far to reach water-related recreation facilities;

c) commuter costs could be reduced if homes and work places were not separated by such large, open spaces.

UNPRICED COSTS OF THE MARINA PROJECT

A. REDUCED LANDSCAPE DIVERSITY AND AESTHETIC QUALITY

The variety and beauty of the present landscape would be diminished by the loss of open space, natural features, and biological elements, all of which act as a "green lung" for the urban environment.

a) The loss of open space and natural features in a predominantly built-up area will make the landscape more uniform and monotonous;

b) increases in litter, sewage, and other wastes may have aesthetic impacts within the project area and in adjacent areas (both land and sea);

c) the aesthetic quality of the water resource could very possibly deteriorate due to increased pollution, nutrient-enrichment (from sewage and run-off), siltation, hydrogen sulphide production, and decay of algae and macrofaunal elements (from stagnation, stratification, and de-oxygenation);

d) the destruction of biological habitat and sources of primary production would reduce the numbers and therefore the pleasing visual and auditory impacts of some populations, particularly highly-valued species of water birds;

e) modifying this natural system will reduce opportunities for local and regional residents to satisfy their psychological need for contact with nature;

f) the present focus of the community - the vlei and lagoon - would be irreversibly disrupted.

B. INCREASED RISK OF LOSING BIOLOGICAL RESOURCES

Potentially valuable genetic information could be lost if habitat destruction reduces gene pools beyond safe levels:

a) the loss of highly productive wetlands will reduce critical habitat available to certain rare and endangered species;

b) another link in the system of wetlands used by migratory species of water birds will be eliminated, and this could endanger the viability of some populations;

c) reductions in local plant and animal populations due to habitat destruction and disruption of ecological processes may threaten general losses of genetic diversity and co-evolutionary developments of scientific interest.

C. LOST OPTIONS

Valuable ecological functions and resource options may be lost and higher-order impacts may be suffered, when the natural environment is substantially altered:

a) impacts on such natural processes as water, nutrient, and sediment cycling could lead to costly resource shortages and ecological problems;

b) if sufficient representative samples of the biophysical environment are not maintained, valuable options for the future utilization of natural resources will be foregone;

c) other development options for this area would be eliminated;

d) large-scale modification of the natural environment may lead to significant higher-order impacts which are now unforeseeable.

D. LOST LEGACY

Part of society's natural and cultural heritage would be irretrievably lost:

a) an area of historical interest would be lost, including historic structures (e.g., the wooden bridge) and natural features (e.g., the vlei, which featured in many early maps and diaries);

b) the only area in the region which features the juxtaposition of river, vlei, dunes, and lagoon would be irreversibly altered;

c) the knowledge that another natural and historical area has been lost, and fewer such places now exist, would be of concern to non-visitors as well as visitors;

d) the country's scientific and political standing could be reduced by proceeding with the project since South Africa is a signatory to the RAMSAR Convention, which is intended to protect significant wetland areas for aquatic bird-life.

E. LOST EDUCATIONAL AND RESEARCH FACILITY

The opportunity to provide over 400 schools and colleges, as well as other educational and research organizations, with a "natural classroom and laboratory" would be lost:

a) students in the metropolitan area would lose an opportunity to get direct lessons in nature study in an interesting transitional zone where several ecosystems meet (e.g., riverine, freshwater wetland, estuarine, dune, marine, terrestrial, urban, etc.);

b) an opportunity to promote greater awareness of nature in an urban population through direct contact with a natural system would be lost;

c) a natural laboratory for ecosystem research, including basic ecosystem functioning, monitoring of pollution impacts on natural ecosystems, and rehabilitation of damaged ecosystems, would be lost.

F. LOST RECREATION AND TOURISM BENEFITS

Opportunities for several outdoor recreational pursuits will be diminished, and the area's appeal to tourists may be impaired:

a) reducing the area available for golf, hiking, bird watching, horse riding, trail bike riding, flying model aircraft, etc. would deprive metropolitan Cape Town's large and rapidly growing population of recreational opportunities- this could increase sociological pressures, decrease the efficiency of the local work force, and lower the overall quality of life for urban residents;

b) the recreational utility of the area's water resources could be significantly reduced if water quality in the dredged lake and lagoon system deteriorates (due to difficulties in maintaining constant levels, adequate depth, mixing, purity, etc.);

c) tourists attracted by the S.W.Cape's natural amenities may feel there is less of interest to see in the area, and tourism revenues (which are important to the regional economy) could stagnate or decline.

G. INCREASED FLOODING RISKS

The natural flood absorbing and attenuation capacity of the vlei will be lost and flood controls to compensate for the loss of the floodplain may prove inadequate:

a) homes in the surrounding area, as well as marina homes, may be subject to flood damage;

b) extreme floods would threaten residents in the flood zone with injury or loss of life.

H. INCREASED POLLUTION RISKS

Pollution impacts could increase if the assimilative capacity of the existing ecosystem is reduced while the built environment is expanded:

a) increased sewage, industrial effluent, and pathogen levels could result in the spread of water-borne disease;

b) the loss of vegetation in an area subjected to significant levels of air pollution may increase health hazards;

c) higher pollution levels could damage property and increase maintenance costs;

d) pollution impacts could lower property values in the area.

I. INCREASED CONGESTION EFFECTS

The influx of new residents and visitors could exceed the optimal carrying capacity of the area so that the quality of life of present residents and users would be significantly reduced:

a) increased noise and water pollution from boats on the new lake may disturb present residents;

b) greater traffic congestion in the local area may increase travel time and psychological costs for present residents;

c) greater demand for improved roadworks could lead to higher rates and taxes;

d) some of the area's present residents could have views blocked or spoiled;

e) present residents who were attracted to the area by the existing conditions and atmosphere might regret that the character of the area has been dramatically altered;

f) increased crowding of water areas, beaches, and dunes will degrade certain aspects of these features, or inhibit some uses;

g) overuse of the area's amenities may necessitate bothersome regulations and expensive control measures;

h) increased demand for utilities and services may overload the infrastructure, causing breakdowns in basic community services.

J. INCREASED SOCIAL TENSION

The marina project could create greater social pressures:

a) existing social and racial animosities could be exacerbated by resentment that a general amenity will be lost and only a few privileged families (those who live in the new development and those who can afford boats) will significantly benefit from the project;

b) because of Group Areas legislation, the scheme will substantially increase regional inequity;
c) the long construction period could disrupt the Milnerton area for much of the 47 years which will be required to complete the project;
d) there is a possibility that the project may not be satisfactorily completed or maintained due to changes in market conditions, or a lack of resources or skills on the part of the developer or the municipality;
e) the general community may be required to carry a significant financial burden (due to long-term maintenance of the scheme) on behalf of a privileged few.

ILLUSTRATIVE MATERIAL

APPENDIX FF

Extract from Impact Report - Case Study 3 (Rietvlei)

(Excerpted from Stauth, 1983b, pp.113-138)

NOTE: The following material is intended to illustrate the content of an impact report. The impact report for this case study was never completed because while investigations were in progress, a decision was taken by the authorities to proclaim the area as a nature area. Since there was no longer any need or justification for undertaking an expensive research effort, data collection and analysis was terminated. As a result, some of the material and conclusions presented in this appendix are based on superficial investigations and/or hypothetical data, but an attempt has been made to make the analysis correspond to reality as closely as possible to illustrate the recommended data-gathering procedures and report format.

For the purpose of illustration, the first two impacts associated with each proposal have been selected. For the Nature Area Project these are: "Noise Pollution" and "Undesirable Biological Elements"; for the Marina Project these are: "Reduced Landscape Diversity and Aesthetic Quality" and Increased Risk of Losing Biological Resources".

7.6.1 UNPRICED COSTS OF THE NATURE AREA PROJECT: NOISE POLLUTION

a) General Nature of Impact

The noise from certain recreation activities, such as power boating, trail-bike and beach-buggy driving, and model-aircraft flying, may disturb residents in the area (particularly on Sundays), as well as other recreationists, such as bird-watchers and nature students. Even moderate levels of engine noise may be disturbing because many people are attracted to natural areas partly because they are quiet places, and the sounds of mechanized vehicles may seem incompatible with the nature area concept.

b) Magnitude of Impact, and Probability of Occurrence

All the noise-polluting activities of concern currently take place in the area, and although these activities may be expected to increase if a nature area is proclaimed and use is not restricted, the area is already well-utilized by power boaters, trail bikers, and model-aircraft flyers and therefore current noise levels should provide a reasonable indication of the possible extent of the problem. Noise impacts were assessed in two ways:

i) Sound Level Meter measurements were taken at various points around the vlei and at houses adjoining the vlei, and

ii) Several residents were interviewed to determine if and when noise levels were disturbing.

The South African Bureau of Standards maximum basic noise level for suburban residential outdoor spaces with little road traffic is 50 decibels (dB). In the evening and on week-ends, the maximum level is 45 dB, and at night it is 40 dB. Sound level measurements were taken under no-wind conditions on 26 and 27 March 1983 from 13h00 - 18h00 with a B & K sound level meter, serial number 2215, calibrated and found correct at 94 dB on A scale 26 March 1983. Results of the measurements are summarized as follows.

Power boats: Readings up to 77 dB were recorded in the vicinity of the clubhouse on the northern side of the lake, but readings at the nearest houses in Table View Township were less than 40 dB. Readings in the area of the bird sanctuary and on the dunes and beaches were less than 40 dB. Residents interviewed in the area adjoining the Milnerton Aquatic Club stated that the power boats were not disturbing and pointed out that boating noise associated with a large marina scheme could generate even more noise.

Trail bikes: Trail bikes operating at the extreme northwestern corner of the vlei produced readings from 50 to 60 dB in the gardens of the nearest homes, but readings elsewhere in the vlei and on the dunes and beaches were under 40 dB. (No beach buggies were operating, but it is believed their operational area and noise level would not exceed that of the trail bikes.) Local residents stated that trail bike noise was sometimes disturbing, but generally there were no problems when the bikes stayed on the western side of the vlei.

Model aircraft: Readings in residential areas, the dunes, the beaches, and the bird sanctuary were under 40 dB. From the Cape Radio Flyers' airstrip, decibel fall-off with distance was plotted with the following results: 70 - 80 dB up to 100m; 60 - 70 dB up to 200 m; 50 - 60 dB up to 300 m; 40 - 50 dB up to 400 m; less than 40 dB beyond 400 m. None of the residents complained about model aircraft flying.

c) Potential Effects on Social Groups Differently Affected

i) Local residents appear not to be adversely affected by present noise levels, with the possible exception of Table View residents on Pentz Drive who are occasionally disturbed by trail bikes. Power boats appear to concentrate along the southern and eastern shores which are far from residential areas.

ii) Bird watchers should not be disturbed in the bird sanctuary area.

iii) Hikers and picnickers could be disturbed by model airplane flyers, particularly if there are no restrictions on free-flying with radio-controlled planes. The whine of these small engines could adversely affect people wanting to escape to a nature area from the urban areas. (Public action to control this activity has been taken in the Stellenbosch and Kenilworth areas.)

d) Timing, Duration, and Potential Reversibility of Impact

The impact would be immediate and could be expected to grow over time until significant conflicts develop as the area's carrying capacity is approached. If the impact is eventually found to be unacceptable, it could be eliminated by simply banning offending activities. There would be no irreversible consequences.

e) Special Risks and Secondary Impacts

Noise pollution, particularly from trail bikers and beach buggies, may promote the notion that natural, open spaces constitute "waste ground" and this might erode the environmental ethic which a nature area is presumably intended to inculcate.

It is possible that if noise levels pass some ill-defined but critical threshold, the value of certain recreational activities will be diminished and users will be driven away. If management is not imposed, the outcome of competition for a multiple use, common property resource could be a gradual monopoly of the resource by the group generating the largest negative externality (and externality effects may also favour recruitment to the externality-imposing activity).

f) Mitigating Measures

Noise from power boats could be controlled by putting restrictions on speeds of operation. Noise from model airplanes could be controlled by demarcating the radius of permissible operations from a central point. Noise disturbance from all recreational activities could be controlled by limiting times of operation (e.g. 09h00 - 18h00), and by dense tree-planting to screen sensitive areas.

7.6.2 UNPRICED COSTS OF THE NATURE AREA PROJECT: UNDESIRABLE BIOLOGICAL ELEMENTS

a) General Nature of Impact

Marshy, open spaces might harbour certain undesirable species which could become a health hazard or a nuisance to residents of the area. Snakes and mosquitoes might proliferate and annoy local residents, stray cats and dogs might occupy the area and become scavengers in adjoining neighbourhoods, and large flocks of birds might damage or kill trees in favoured roosting areas and might constitute a hazard to low-flying aircraft from the nearby Ysterplaat Air Force Base.

b) Magnitude of Impact, and Probability of Occurrence

Health officials say that there are no records of disease or injury due to undesirable biological elements in the area. Residents on the perimeter of the vlei-lagoon and officials with local knowledge were interviewed, and field investigations were conducted, to determine the present magnitude of other potential problems.

Residents could not recall any instances of snakes being found in local gardens except during extreme flood events. The Cape dobra (Naja nivea) used to be common in the area but is now rarely seen. Other snakes known to inhabit the area are considered harmless and even beneficial, since they keep rodent populations in check (signs on the golf course ask people to leave snakes alone). These species include the molesnake (Pseudaspis cana), Cape slugeater (Duberria lutrix), African egg-eater (Dasypeltis scabra), and spotted skaapsteker (Psammophis rhombeatus). Nature Conservation officials maintain that these snakes are unlikely to leave their natural habitat in the vlei-lagoon area itself.

Residents are sometimes troubled by mosquitoes in summer evenings and nights, but the general feeling was that the problem is not serious and probably no worse than in many other areas. Nature Conservation officials maintain that small, stagnant water bodies are the major breeding areas of mosquitoes, and the large, open, fresh water bodies of the vlei-lagoon are not a major problem. Plankton tows for mosquito larvae in standing pools of water were negative.

There are few large trees in the surrounding residential area that might attract roosting birds, and no signs of roosting (dropping or damage) were noted.

The Ysterplaat safety officer and officials with air traffic control report that there are no records of bird strikes by aircraft in the area. Birds using the vlei apparently stay away from the airfield and below the height of approaching and departing aircraft when the latter pass over the vlei (generally in excess of 1000 feet above ground level).

Field surveys revealed no signs of cats or dogs, and none of the residents interviewed recalled seeing feral cats and dogs in the vlei. SPCA officials have had no complaints of stray animals. The vlei-lagoon is not an attractive environment for strays and they probably prefer to scavenge in more built-up areas.

Since implementation of the nature area project should not substantially change existing conditions, and there appear to be no notable problems associated with undesirable biological elements at present, there is a high probability that the magnitude of this impact will be nil.

c) <u>Potential Effects on Social Groups Differently Affected</u>

i) <u>Local residents</u> (in the immediate vicinity of the vlei-lagoon) are more likely to be disturbed by snakes, mosquitoes, birds, and stray animals than other Table View and Milnerton residents, but this should not become a significant problem.

ii) <u>Visitors</u> to the nature area should not be disturbed by biological elements which are regarded as part of the natural conditions.

iii) <u>Military aircraft crews and passengers</u> could be subjected to some slightly increased risk from bird collisions, particularly during periods of poor visibility.

d) Timing, Duration, and Potential Reversibility of Impact

The impact would be immediate (but should not vary significantly from present levels), lasting, and reversible.

e) Special Risks and Secondary Impacts

None.

f) Mitigating Measures

According to health officials and the Town Engineer, mosquito-breeding areas could be sprayed with chemicals if a problem developed.

If roosting birds became a problem, roosting platforms could be created in the vlei, and various measures could be taken to frighten off flocks of birds from adjoining neighbourhoods (e.g. scarecrows, explosions, model airplane flights, fire hoses, etc.).

If the potential for bird strikes increased, approach and departure patterns at Ysterplaat might be modified.

7.6.3 UNPRICED COSTS OF THE MARINA PROJECT: REDUCED LANDSCAPE DIVERSITY AND AESTHETIC QUALITY

a) General Nature of Impact

1. Urban ecologists, planners, and landscape architects suggest that open, natural spaces relieve the monotony of the built environment and planned open spaces in urban areas. The major natural features of the Rietvlei-Milnerton Lagoon system, such as the freshwater marshes and the lagoon itself, are relatively unique in the southwestern Cape, and the loss of a rare natural area within the urban environment might be expected to reduce the scenic and amenity value of the community. Rietvlei is one of the last viable wetland systems in the southwestern Cape, since most of the vleis in the area have been drained, filled, or otherwise modified in the past thirty years. For example, Sandvlei was dredged to allow more boating and construction of the Marina da Gama, a weir was built at Seekoevlei to maintain the water level, the Black River and Krom River marshes were overbuilt, and many streams have been canalized or piped. The loss of Rietvlei's natural features might be expected to further reduce landscape diversity and the aesthetic value of the Cape Metropolitan Area, and the loss of general open space may have subtle psychological and sociological effects on residents in the affected communities. In addition to a sense of crowding and a loss of contact with natural elements, local residents could feel a sense of deprivation or alienation since the vlei has served as a community focus and a source of local pride.

2. The influx of 30 000 people might result in great aesthetic impacts from more litter, sewage, and other wastes within the immediate area and also adjacent land and sea areas. For example, an extension of the present sewage works might make this facility more visible and result in more offensive odours in the area, and it might be necessary to request relaxation of certain standards and construct a sewage outfall off the coast, which could then have adverse impacts on the marine and coastal environments. Sewage effluent could also create pollution hazards in the marina's water body, and litter could accumulate around the lake's shoreline. In addition, the incineration of locally-generated solid wastes could contribute to the area's air pollution problems if disposal areas are too far or could not be sealed to prevent seepage into groundwater supplies.

3. Water quality control is a notoriously difficult problem for marina projects. Evaporation will significantly increase salinity concentrations if there is no diluting or flushing by fresh water inflow, and this could eventually render the water body sterile. Dense sea water used to maintain water levels could settle to the bottom, as has happened in parts of Sandvlei, leading to poor water circulation and anoxic conditions. Bridges and embankments could reduce waterflow and alter circulation patterns. Poor circulation and flushing could result in greater siltation, deoxygenated areas, dead fish, algae decay, hydrogen sulphide production, concentrations of pollutants, and high coliform counts. Stormwater drainage from the expanded urban area and run-off from gardens and surrounding agricultural developments could bring in high nutrient loads, which could result in unsightly algae blooms, and

possible concentrations of toxic elements which are difficult to flush out.

Without natural marsh vegetation acting to filter and purify the water, the water body could come to resemble an open sewer. If the assimilative capacity of the water body is exceeded, anaerobic conditions will develop in still areas or canals between housing areas, especially on southern shores, and the decay of algae and macrofaunal elements could be aesthetically offensive. If such effects become frequent and widespread, property values in the surrounding area may decline as the area's optimal carrying capacity is exceeded, and large capital investments may be necessary to keep environmental quality from declining further. This could result from fragmentation of the area's holistic ecological value from disturbances to the inflowing Diep River, the floodplain's wetland area, the dredged deep water basins, and modifications to the lagoon.

4. The destruction of biological habitat will reduce primary and secondary productivity and the sizes of populations of many organisms. The numbers of fish and invertebrates (including bait organisms) could be reduced due to poor water exchange or circulation, leading to stagnant backwaters. Dredging and filling will reduce shallows needed by wading birds for feeding, reduce suitable areas for macrophytes to root, create greater danger of an anoxic bottom zone and stratification of the water body, and increase siltation impacts (such as the smothering of benthic organisms). Filling, as well as the need for water level control, will also reduce the extent and variability of wetlands. The loss of marshy

areas will reduce detritus input to the system, which is the basis of the wetland food chain. The loss of mudflats will affect wader populations, and the loss of marginal vegetation and other critical habitats will reduce the diversity and numbers of birds frequenting the area, particularly those species which require undisturbed wetlands for some part of their life cycle. A further reduction in the numbers of birds and animals to be seen and heard in the southwestern Cape could constitute a significant loss in the general amenity value of the region.

5. Many anthropologists, psychologists, social philosophers, and human ecologists say that man appears to have an inherent psychological need for contact with nature, and the marina project would substantially reduce the opportunity for such contact for a large number of people.

b) Magnitude of Impact, and Probability of Occurrence

1. In order to determine the relative uniqueness of the Rietvlei system, a method developed by Leopold and Marchand (1968) was employed. A number of factors were chosen to represent aspects of wetland systems, and twenty wetland systems in the southwestern Cape were then evaluated in terms of these factors. Each factor for each site was then expressed as a uniqueness ratio so that average uniqueness scores could be calculated for all sites for any particular groups of factors and sites. Rietvlei was judged to have relatively high uniqueness scores in terms of factors selected by conservationists as being important aspects of natural environments.

In addition, an assessment of the aesthetic quality of the Rietvlei area relative to that of other well-known features of the Cape Metropolitan area (both natural and man-made) was undertaken following the method developed by Linton (1968). The Rietvlei system was found to rank high in aesthetic quality in comparison to many features of the local environment, including Marina da Gama and Sandvlei.

Nevertheless, many residents who were interviewed in the Milnerton/Table View area considered the vlei to be a drab and uninteresting area, while they regarded the proposed marina project as a novel element that would offer more interest and variety to the landscape. The majority expressed the opinion that the vlei was a "wasteland" and not "useful or attractive open space", whereas a properly planned marina would be an asset to the surrounding community and would constitute a new and better focus for the community.

2. Litter accumulation could be a problem since river flow is very low most of the year, and there will be no flushing to the sea due to the weir. With 30 000 new residents in the area, litter impacts would also be significant on nearby beaches and dunes.

Litter surveys were conducted in the Rietvlei area, and also at Marina da Gama and the Cape Point Nature Area for comparative purposes. Very little litter or signs of dumping were found in the latter areas, whereas large amounts of litter were found around the perimeter of Rietvlei, along tracks through adjacent dunes, and along the high-water level of the beach. In addition, a large amount of dumping has taken place on the northern edge of Rietvlei and parts of the lagoon. Large amounts of litter were also found along the lagoon, particularly near the mouth.

The widespread perception of Rietvlei as a "wasteland", along with easy access and no effective control on entry, has no doubt contributed to the litter and dumping problem. While proclamation of a nature area should change these perceptions and behaviour patterns, it seems reasonable to assume that the marina project might have even less litter and dumping since residents will be motivated to look after their own neighbourhood.

Investigations were also conducted into the sewage disposal conditions of the Rietvlei area. According to the Milnerton Town Engineer, all sewage effluent is used to fertilize public open spaces in the summer and therefore no effluent enters the vlei except in winter, and this is treated effluent. However, total nitrogen and phosphate levels exceed 2 m g/ℓ and volatile solids and chemical oxygen demand are relatively high. If necessary the present works could be extended into an area of reeds which has been excluded from the nature area, and a pipeline could be constructed through an existing servitude in the vlei to a marine outfall. Health authorities are satisfied that projected treatment rates for the marina project would pose no health problems due to good dispersal conditions offshore, and then no effluent would enter the marina water body.

Enquiries into sewage disposal conditions at Marina da Gama revealed no problems either in the project area or adjacent land and sea areas, except when sewage pump stations overflow (a rare event), and then the water is treated with a proprietary hypochlorite powder ($NaHClO_3$). There appears to be no reason to believe that sewage disposal impacts associated with a marina project at Rietvlei would be of any notable magnitude.

Finally, industrial effluent is piped to the sea (although there have been leakages reported in the past), and since suitable disposal sites are available at reasonable distances, solid waste incineration should not be necessary.

3. Comparisons of water conditions at Sandvlei, site of the long-established Marina da Gama scheme, to those at Rietvlei may be useful in assessing the potential impacts of a marina scheme on Rietvlei's water quality. Water quality tests were conducted at both Sandvlei and Rietvlei. Investigations included tests of water and sediments for oil, detergents, pesticides, asbestos, rubber, and heavy metals, as well as for phosphates and nitrates. Total coliform and E. coli counts were also made, and pH, salinity, and dissolved oxygen were measured. Possible siltation and turbidity problems were assessed by taking samples of inorganic settleable solids and bottom sediments, and measuring turbidity. Samples were also taken of algae and aquatic weeds and biomass estimates were calculated. Surveys of aquatic flora and fauna were done to assess species diversity, estimate population sizes, and record pollution indicator species.

Rietvlei's water quality is reasonably good. Faecal bacterial contamination is relatively high due to the bird population (an E. coli concentration on the order of 100/100 mℓ) but this is not considered hazardous to health. Salinity and nutrient levels at the Diep River inlet are high, presumably due to salts in the Malmesbury Shales in the catchment and dairy farming in the catchment. However, within the vlei-lagoon system nutrient levels are not excessive and there are no indications of eutrophication or industrial pollution (Caltex and Fedmis pipelines carry effluent to the sea). Oxygen levels are normal, and there are no signs of stratification, probably due to wind-generated turnover in this fairly shallow water body. There are dense reedbeds at the Diep River inlet which act as a sediment trap, however sediment loads in the river are high - particularly during flood events - and if these reedbeds are removed in order to extend the sewage works (as has been suggested), the vlei could experience rapid siltation.

Sandvlei's water quality does not compare favourably with that at Rietvlei. There are high nutrient loads, which has led to a major weed harvesting problem. Bottom dissolved oxygen values of zero have been recorded in the marina canal system and in the main vlei basin. Anaerobic conditions lead to the formation of hydrogen sulphide gas, which is a source of noxious odours when wind-induced mixing occurs. (While the extensive beds of Potamogeton pectinatus assist in oxygenation of the water body, these weeds obstruct yachting activity and so must be held in check.) Because water circulation is poor, due largely to attempts to provide sheltered conditions for marina housing and canals, it may be necessary to instal expensive pumps at a number of points to oxygenate the water.

The Sandvlei water body has low species diversity, the siltation rate appears to be high, coliform counts are excessive (exceeding standards set for the European Economic Community), and tests for oil, detergents, pesticides, asbestos, and rubber were all positive. While none of these problems is yet serious (with the exception of the proliferation of aquatic macrophytes and H_2S odours), there are indications that the situation is gradually worsening.

Maintaining water quality of the proposed marina water body at Rietvlei is likely to be difficult and expensive. Siltation rates will probably increase, especially if reed beds are removed, necessitating fairly frequent dredging. Water circulation and stagnation problems could occur during the frequent low flow periods, since the vlei is not tidal and the lagoon mouth will normally be closed. There is also the possibility that excessive chlorinities could eliminate much aquatic life. Nutrient enrichment will increase, leading to algae blooms and an expensive weed harvesting programme, like the one at Sandvlei. Occasional anoxic conditions could lead to fish kills, decay of aquatic plants, and releases of hydrogen sulphide. The water could also become turbid and unsightly. Further business and industrial development in the area, as well as the large number of houses and roads constructed for the marina, will become an additional source of toxic elements to the lake.

There seems to be a high probability that water pollution will sometimes become severe in parts of the marina, and perhaps occasionally over most of the water body, unless the need for very careful planning and high outlays on pollution control are recognized and accepted.

4. Flora and fauna surveys were conducted and comparisons made to other vlei systems in the southwestern Cape. Rietvlei is a potentially rich feeding ground and nursery area for fish, and is one of the last major habitats for migratory water birds in the area.

Because the water area is large and shallow, sunlight penetrates to the bottom and wind mixes the water so that primary production is high. Large tracts of freshwater marsh are a source of detritus which constitutes the base of the food chain and enables large populations of many species to be supported by a small area. The marshes, as well as the reedbeds and other marginal vegetation, provide cover and nesting materials for animals and birds. When the water recedes, large mud flats are exposed and wading birds feed on densely concentrated burrowing organisms.

One hundred and sixty-three species of birds have been recorded at Rietvlei, and for several species the numbers of individual birds sometimes run into the thousands. There are no other natural wetlands in the western Cape where such large numbers of breeding water birds can be found. Because of the size and nature of the area, flocking of waterfowl occurs; this probably promotes pairing, after which the birds disperse all over the western Cape with the advance of the rainy season. Since there are no comparable areas in the western Cape where flocking can take place on such a scale, the loss of this biological habitat and disruptions to ecological processes affecting the food web (e.g. dredging, filling, etc.) would reduce the breeding potential and thus the numbers of several populations, which would affect the aesthetic quality of Rietvlei and a much wider area (including overseas regions visited by migratory water birds). While there might be an increase in the numbers of ducks and coots due to greater productivity from aquatic macrophytes, the loss of marshes and other biological habitat would reduce the numbers of many water birds.

Although it is difficult to estimate the impact on breeding success and survival of water birds if this habitat is destroyed, there is a reasonably high probability that noticeably fewer pelicans, reed cormorants, spoonbills, white storks, and migrant waders would frequent the Rietvlei, Cape Metropolitan, and western Cape area.

5. A survey of residents indicates that although people widely believe that contact with the natural environment contributes positively to psychological well-being, there are limited opportunities for experiences with the natural environment, and most people are not prepared to spend much money, time, or effort to achieve such experiences. The most popular outdoor activity in the area is walking on the beaches. Very few people regularly visit parks or natural open spaces, including Table Mountain and the Cape Point Nature Reserve, yet many said they would regularly visit a nature area at Rietvlei because of its proximity to their homes. The major reasons for wanting to make such visits were (1) an opportunity to walk (physical exercise) in a peaceful setting, (2) viewing water birds, and (3) having family picnics and braais. The marina project would mean that local populations would lose the opportunity to enjoy convenient, frequent, and intimate contact with the natural environment.

c) Potential Effects on Social Groups Differently Affected

i) Local residents (in the immediate vicinity of the vlei-lagoon) will forego benefits associated with open space and natural areas, and could suffer losses in property values if pollution impacts occur.

ii) Regional residents might feel that the variety and beauty of the Cape Metropolitan Area has been reduced to a notable degree.

iii) Lower and middle socioeconomic groups (such as residents of Atlantis and Bothasig) will be deprived of the opportunity to experience amenities associated with a nature area situated at a reasonable distance from their homes.

iv) Middle to higher socioeconomic groups (who can afford housing in the marina development) will have an opportunity to live in a unique and attractive situation.

v) Conservationists will lose an area with valued natural features and biological elements.

d) Timing, Duration, and Potential Reversibility of the Impact

The impact would be felt immediately as the vlei is dredged and wetlands filled, and would increase over an ensuing period of approximately 50 years as a steady succession of housing projects are initiated. While pollution impacts are potentially reversible, the loss of open space, natural features, and biological elements may be regarded as essentially irreversible.

e) Special Risks and Secondary Impacts

The loss of landscape diversity and aesthetic quality in an urban environment could have profound psychological and sociological effects. Reduced opportunities for contact with nature could lead to "de-natured man", characterized by a growing insensitivity to natural beauty, a growing vulnerability to stress, and other effects.

Social tension may be exacerbated if large, underprivileged groups are deprived of natural amenities so that a privileged few can live in a unique housing development.

There could be unforeseeable costs associated with inadequately understood ecological functions and potential uses of the system. For example, there may be considerable danger of degradation of the adjacent dunes and beaches. This could result from uncontrolled access of the marina's 30 000 residents to the sea, and degradation would affect the dynamic stability of the land/sea interface and could lead to erosion, beach starvation and sand blows. In addition, secondary and higher-order impacts could ultimately affect other complex coastal and marine systems in ways which are presently unforeseeable but which would adversely affect social well-being.

f) Mitigating Measures

Littering and dumping impacts can be minimized by the provision of litter bins, erection of notices and fences, installation of refuse traps, enforcement of existing legislation, and an effective, on-going clean-up programme.

Pollution impacts from sewage and solid waste can be minimized by constructing adequate treatment plants and developing effective disposal procedures.

Water quality can be maintained by providing water circulation systems, harvesting weeds, and dredging silt to the extent required.

There are no measures which can be taken to significantly reduce impacts to biological habitat in the area; however, it may be possible to undertake a shadow project to establish an equivalent area of habitat elsewhere in the region. Such a development might also serve to provide local residents with some contact with a "natural" environment, particularly with highly-valued biological elements, such as water birds.

7.6.4 UNPRICED COSTS OF THE MARINA PROJECT: INCREASED RISK OF LOSING BIOLOGICAL RESOURCES

a) General Nature of Impact

Several rare and endangered species of birds, including pelicans, flamingoes, and spoonbills, regularly frequent the Rietvlei area. These species are threatened by reductions in critical habitat, and since suitable wetland habitats are rare in the western Cape, locally as well as internationally rare water birds may disappear from the southwestern Cape. The loss of Rietvlei may significantly reduce the breeding sucess of some species which require large wetland areas for flocking and pairing during the breeding season.

Migratory species of water birds require a system of wetlands along their entire migration route for resting and feeding, and Rietvlei may be an important link in the system. There are relatively few wetland systems in the southern hemisphere, and therefore these are considered vitally important to complement conservation areas in the northern hemisphere. South Africa is a signatory to the RAMSAR convention and so has an international obligation to protect major, unique wetland areas.

Since Rietvlei-Milnerton Lagoon is a unique, isolated, and sizable coastal system in the southwestern Cape, it may be of special interest in maintaining gene pools and permitting co-evolutionary developments of some significance. The construction of roads, houses, and weirs would result in barriers to the exchange of physical and biotic elements, and dredging, filling, and building would eradicate an array of biological niches. Because strict water-level control will prevent the system from functioning as a natural wetland system, the gene pools of some estuarine- and vlei-dependent species may be reduced and natural ecological processes will be disrupted.

b) Magnitude of Impact, and Probability of Occurrence

All rare and endangered species inhabitating or frequenting Rietvlei were listed. Then habitat requirements for each of these species were listed, and the regional availability of these habitat requirements plotted. Various investigations were conducted to assess the relative productivity of these areas, and the degree of dependence of each rare or endangered species on each area. For example, distances between potential nesting and feeding areas were calculated; migratory patterns were recorded; estimates were made of present population sizes; and, through an assessment of population dynamics, estimates were made of "critical population sizes" (i.e. numbers necessary to maintain a viable population).

This analysis indicated that Rietvlei constitutes a significant proportion of the available habitat requirements for pelicans, spoonbills, and flamingoes in the southwestern Cape, so that there is a high probability that population numbers could be reduced by x% to y%, thus diminishing the gene pool and possibly endangering the viability of these populations.

No other rare or endangered species, or ecosystems or ecological processes of special interest, were identified for the Rietvlei-Milnerton Lagoon system, and the diversity index was found to be low. The lagoon is of local interest only. There is, however, a possibility that some of the crustaceans found in the lagoon may be of special interest, but this requires further investigation.

c) <u>Potential Effects on Social Groups Differently Affected</u>

i) <u>Birdwatchers and conservationists</u> would be adversely affected by further losses of rare and endangered species of water birds.

ii) <u>Ecologists and other scientists</u> would be adversely affected by the loss of an ecologically-interesting area about which much remains to be discovered and which could serve as a natural laboratory for ecosystem research.

d) Timing, Duration, and Potential Reversibility of the Impact

The impact could be gradual and may not be felt for some years, but it would be permanent and irreversible.

e) Special Risks and Secondary Impacts

The loss of species may have significant but unforeseeable long-term ecological effects, such as outbreaks of pest species, and could involve the loss of genetic materials for undiscovered uses for food, medicine, and other applications.

Violations of the RAMSAR convention could reduce South Africa's scientific and political standing overseas.

f) Mitigating Measures

Populations of concern may be saved by implementing shadow projects which involve the provision of sufficient habitat requirements in areas situated near nesting grounds or along migration routes at suitable locations. However, no shadow project can be expected to provide a satisfactory substitute for any complex ecosystem, and nothing can be done to mitigate losses of co-evolutionary developments within the existing natural system.

7.7 Due to various constraints on the study, a Summary of Potential Environmental Impacts was not prepared in this case, and the evaluation panel received only the Environmental Evaluation Proposal and the Impact Identification Report.

ILLUSTRATIVE MATERIAL

APPENDIX GG

Criteria Assessment Questionnaire

(Excerpted from Stauth, 1983b, pp.279-285)

CRITERIA ASSESSMENT

INSTRUCTIONS

This form is intended to guide a comparative analysis of alternative plans, using three criteria for assessing the significance of impacts to social well-being: (1) efficiency effects, (2) equity effects, and (3) intergenerational effects. The form consists of a series of questions which should be considered during the evaluation process; brief answers to the questions should be written out on a separate piece of paper, both to help clarify one's thinking, and for later reference when drafting the Evaluation Statement. (Note: Although intransitive judgments are possible, the procedure employed here, which ensures that a systematic and explicit appraisal of the plans is undertaken, will greatly assist in identifying the plan which best meets the selection criteria.)

PART ONE - EFFICIENCY EFFECTS

1. For each pair of plans in turn, choose between the outcomes presented below in order to rank plans according to the efficiency criterion. (Note: When making efficiency assessments, it should be assumed that some mechanism will be found for distributing costs and benefits fairly; i.e. those who bear excessive costs will be adequately compensated.)

1.1 Plan A vs. Plan B

CHOICE:

☑ Outcome I - Today's society must bear the cost of Impact X resulting from Plan B, but will gain Y Rands in benefits.

☐ Outcome II - Today's society will avoid the cost of Impact X resulting from Plan B, but must forego Y Rands in benefits.

(Note: If Outcome I is selected, Plan B is more efficient than Plan A.
If Outcome II is selected, Plan A is more efficient than Plan B.)

JUDGMENT: Plan B is more efficient than Plan A.

1.2 Plan A vs. Plan C

CHOICE:

☑ Outcome I - Today's society must bear the cost of Impact W resulting form Plan A, but will gain Z Rands in benefits.

☐ Outcome II - Today's society will avoid the cost of Impact W resulting from Plan A, but must forego Z Rands in benefits.

(Note: If Outcome I is selected, Plan A is more efficient than Plan C.
If Outcome II is selected, Plan C is more efficient than Plan A.)

JUDGMENT: Plan A is more efficient than Plan C.

1.3 Plan B vs. Plan C

CHOICE:

[✓] Outcome I - Today's society must bear the cost of Impact X resulting from Plan B, but will gain K Rands in benefits.

[ ] Outcome II - Today's society will avoid the cost of Impact X resulting from Plan B, but must forego K Rands in benefits.

(Note: If Outcome I is selected, Plan B is more efficient than Plan C.
If Outcome II is selected, Plan C is more efficient than Plan B.)

JUDGMENT: Plan B is more efficient than Plan C.

1.4 After making the above assessments, please rank the plans according to the efficiency criterion in Part Four of this form.

1.5 On a separate piece of paper, note the principal reasons (major assumptions, beliefs, and concerns) for ranking the plans in the order given.

PART TWO - EQUITY EFFECTS

2. For each pair of plans in turn, assess the consequences for different social groups and consider whether the outcome is fair by addressing the following questions to each plan.

i) Which social groups will receive the benefits and which will bear the costs?

ii) How significantly will the well-being of each social group be affected?

iii) Is it likely that redistributive measures can and will be taken (i.e. will those who bear significant costs be compensated?).

2.1 Plan A vs. Plan B

JUDGMENT: Plan A is more equitable than Plan B.

2.2 Plan A vs. Plan C

JUDGMENT: Plan A is more equitable than Plan C.

2.3 Plan B vs. Plan C

JUDGMENT: Plan B is more equitable than Plan C.

2.4 After making the above assessments, please rank the plans according to the equity criterion in Part Four of this form.

2.5 On a separate piece of paper, note the principal reasons (major assumptions, beliefs, and concerns) for ranking the plans in the order given.

PART THREE - INTERGENERATIONAL EFFECTS

3. Consider general implications for future generations by addressing the following questions:

i) What is the likelihood that future generations will not regard projected costs as being significant?

ii) Are future generations likely to be better or worse off than present generations? In what ways?

iii) To what extent should the well-being of future generations be considered in the decision-making process? Should the planning horizon extend beyond one or two generations?

For each pair of plans in turn, assess the long-term consequences by addressing the following questions to each plan.

i) Will benefits still exceed costs over intergenerational time periods?

ii) Are some social groups of future generations likely to bear excessive (unfair) costs?

iii) Are there any special risks or uncertainty about major costs which might afflict future generations? How significant could these be?

iv) Are any costs irreversible? What is the probable significance for future generations of avoiding these costs and keeping options open?

v) Are long-term, secondary and higher-order impacts likely to arise? In what ways could these affect future social welfare?

3.1 Plan A vs. Plan B

JUDGMENT: Plan B would benefit future generations more than Plan A.

3.2 Plan A vs. Plan C

JUDGMENT: Plan C would benefit future generations more than Plan A.

3.3 Plan B vs. Plan C

JUDGMENT: Plan C would benefit future generations more than Plan B.

3.4 After making the above assessments, please rank the plans according to the intergenerational criterion in Part Four of this form.

3.5 On a separate piece of paper, note the principal reasons (major assumptions, beliefs, and concerns) for ranking the plans in the order given.

PART FOUR - TRADE-OFF OF CRITERIA

Final Evaluation Summary:

Efficiency Ranking	Equity Ranking	Intergenerational Ranking
1. Plan B	1. Plan A	1. Plan C
2. Plan A	2. Plan B	2. Plan B
3. Plan C	3. Plan C	3. Plan A

Assessment Procedure:

1. Should the most efficient Plan be rejected because of its unfavourable distributional consequences? YES ___ NO ✓

(IF YES, GO TO 3 - IF NO, GO TO 2)

2. Should the most efficient Plan be rejected because of its unfavourable long-term consequences? YES ✓ NO ___

(IF YES, GO TO 3 - IF NO, GO TO 4)

3. Should the most equitable Plan be rejected because of its unfavourable long-term consequences? YES ✓ NO ___

(IF YES, GO TO 5 - IF NO, GO TO 6)

4. The preferred Plan is the one which is most efficient: Plan ____.

5. The preferred Plan is the one with the most favourable long-term consequences: Plan C.

6. The preferred Plan is the one which is most equitable: Plan ____.

PART FIVE - PERSONAL EVALUATION STATEMENT

Please draft a brief and anonymous Personal Evaluation Statement. This statement should include a discussion of reasons for ranking plans in terms of each criterion, as well as reasons for selection of the preferred plan in terms of all three criteria. The object is to communicate the nature of the assessment process to decision makers and other concerned parties to promote better understanding and better decisions.

ILLUSTRATIVE MATERIAL

APPENDIX HH

Final Listing of Impacts - Case Study 4 (Palmiet)

(Excerpted from Stauth and Lane, 1983, pp.10-18)

II BENEFITS IDENTIFIED FOR EACH PROJECT

Following are the four lists of benefits which will be compared:

PART ONE: Benefits of the Upper Hangklip Dam in Relation to the Lower Hangklip Weir

1A REDUCES ADDITIONAL COSTS TO WATER CONSUMERS

Provides water at lower unit cost and delays the necessity of charging high water tariffs for desalinated water.

1B REDUCES CAPITAL EXPENDITURE REQUIRED

Provides more water storage capacity at lower capital cost and delays the necessity of incurring the high capital cost of desalination.

1C INCREASES RELIABILITY OF WATER SUPPLY

Reduces vulnerability to failures in supply due to mechanical or electrical breakdown when conveying water to other storage areas.

1D PROVIDES HYDROELECTRIC POWER AT ADDITIONAL COST OF R50 MILLION

Supplies 80 MW of power to ESCOM at peak demand periods without further pollution.

1E AVOIDS CERTAIN ADVERSE IMPACTS ON LOCAL RESIDENTS

Involves less disruption to local communities from construction activities, and avoids the inundation of privately-owned land near Kleinmond.

1F CONSERVES LOWER REACHES OF VALLEY

Conserves the valley bottom fynbos communities between the proposed dam wall and the proposed weir.

a) Avoids inundation of riverine and associated ecosystems downstream of dam site;
b) Reduces the impacts of wind-blown sand on vegetation from exposed deposits above low-water mark.

1G CONSERVES CERTAIN AGRICULTURAL LANDS

Avoids inundation of agricultural land in the Arieskraal Dam area.

1H CONSERVES CERTAIN RECREATIONAL RESOURCES

Avoids inundation of recreational areas on the southern boundary of the reserve and maintains more suitable conditions for recreation in the estuary.

1I PROVIDES GREATER OPPORTUNITIES TO IMPROVE ECONOMIC CONDITIONS IN THE KLEINMOND/STRAND AREA

Increases prospects for job-seekers and businessmen during construction phase.

1J AVOIDS CERTAIN AESTHETIC IMPACTS

Reduces loss of scenic quality from certain vantage points.

a) Avoids any adverse visual impacts from vantage points outside the Kogelberg State Forest;

b) Reduces aesthetic impacts to the area by minimizing the fluctuation of water levels;

c) Minimizes aesthetic impacts of wind-blown sand from exposed deposits above the water line.

1K MINIMIZES IMPACTS ON THE PALMIET ESTUARY

Increases the prospects of maintaining natural conditions in the estuary by regular releases from the Dam, and by allowing inflow of natural runoff from the catchment below the dam.

1L IMPROVES FIRE-FIGHTING CAPABILITY

Provides an extensive road system for access for fire-fighting.

1M INCREASES OPPORTUNITIES FOR FLAT WATER RECREATION

Provides a larger, more stable water body for dam-orientated recreational use.

1N INCREASES OPPORTUNITIES FOR PRODUCTION OF BIOTIC RESOURCES

Provides a larger, more stable water body for certain biotic resources.

PART TWO: Benefits of the Lower Hangklip Weir in Relation to the Upper Hangklip Dam

2A AVOIDS CERTAIN ADVERSE IMPACTS ON LOCAL RESIDENTS

Involves less disruption to local communities from an influx of construction workers into the area.

2B AVOIDS CERTAIN AESTHETIC IMPACTS

Maintains much of the aesthetic quality of the Kogelberg State Forest and surrounding areas.

a) Minimizes excavation scars from dam-building activity;
b) Avoids the establishment of more man-made structures within the relatively pristine Kogelberg State Forest.

2C CONSERVES MORE OF THE NATURAL ENVIRONMENT

Minimizes losses of, and disruptions to, biophysical components and ecological processes in the Kogelberg State Forest.

a) Inundates a smaller area of the Kogelberg State Forest's vegetation and avoids destruction of the most valuable of the riverine vegetation communities in the reserve (which are located along the Dwars and Louws Rivers);
b) Results in less destruction of wildlife habitat and fewer disruptions to inter-linked ecosystems;

c) Avoids introduction of invasive exotic plants and animals, such as Australian Acacias and the Argentine Ant, during construction, and for operation and maintenance;

d) Avoids catchment erosion and river sedimentation in the Palmiet Valley which could result from dam-construction and road-building within the reserve.

2D CONSERVES CERTAIN AGRICULTURAL LANDS

Avoids inundation of agricultural and other private land along the banks of the Palmiet and Krom Rivers.

2E CONSERVES SCIENTIFIC AND EDUCATIONAL RESOURCES

Avoids inundation of potentially important research sites.

2F REDUCES RISK OF EXTREME EVENTS AFFECTING THE PALMIET ESTUARY

Prevents the possibility of killing aquatic organisms from releases of anaerobic water to the estuary.

PART THREE: Benefits of the Upper Hangklip Dam in Relation to Desalination of Sea Water

3A REDUCES ADDITIONAL COSTS TO WATER CONSUMERS

Provides water at lower unit cost.

3B ACHIEVES GREATER RETURN ON CAPITAL

Provides water at lower capital cost, and will continue to supply the same annual quantity of water for a significant period after the initial capital expenditure has been redeemed.

3C PROVIDES MORE TIME TO IMPROVE DESALINATION TECHNOLOGY

Postpones need to bear high financial and other desalination costs, which may be reduced by technological advance.

a) Provides time to develop more cost-effective methods of desalination and more efficient disposal of byproducts, and delays the need for an expansion of presently planned control and disposal of waste products from nuclear or coal-fired power stations.

b) Provides time to mitigate aesthetic and ecological impacts of a desalination plant in a coastal location.

c) Provides time to develop acceptable storage facilities for desalinated water.

3D CONSERVES ENERGY RESOURCES

Minimizes energy requirements in meeting water demand, and supplies 80 MW of power to ESCOM at peak demand periods without further pollution or consumption of nonrenewable resources (uranium and coal).

3E INCREASES RELIABILITY OF WATER SUPPLY

Reduces vulnerability of water supply to failures from technical complexity, marine oil pollution, and sabotage.

3F INCREASES OPPORTUNITIES FOR FLAT WATER RECREATION

Provides a large water body for dam-orientated recreational use.

3G PROVIDES OPPORTUNITY TO INCREASE PRODUCTIVITY OF CERTAIN RESOURCES

Provides new habitat for fish, waterfowl, and wildlife and an opportunity for the establishment of large-scale aquaculture or fish breeding/research stations.

3H IMPROVES FIRE-FIGHTING CAPABILITY

Provides an extensive road system for access for fire-fighting.

3I PROVIDES GREATER OPPORTUNITIES TO IMPROVE ECONOMIC CONDITIONS IN THE KLEINMOND/STRAND AREA

Increases prospects for job-seekers and businessmen during construction phase.

PART FOUR: Benefits of Desalination of Sea Water in Relation to the Upper Hangklip Dam

4A HASTENS DEVELOPMENT OF MORE SECURE WATER SUPPLIES

Reduces risks of future water shortages.

a) Provides a source of water which is not dependent on rainfall and which is potentially limitless, thus strengthening the Cape's economic security and South Africa's political security.

b) Provides greater incentives for water conservation (due to higher unit cost of water).

c) Promotes advances in desalination technology and provides impetus for similar developments elsewhere in the Republic.

d) Improves the prospects of a smooth transition from conventional to unconventional water resources.

4B ENHANCES SOUTH AFRICA'S INTERNATIONAL REPUTATION

Contributes to South Africa's prestige and scientific standing in the international community.

4C STIMULATES REGIONAL ECONOMIC DEVELOPMENT

Provides greater employment opportunities and economic stimulus for the area's population, including the opportunity for commercial exploitation of brine produced in the desalination process.

4D CONSERVES NATURAL RESOURCES IN THE KOGELBERG STATE FOREST

Avoids losses of and disruptions to biophysical components and ecological processes in the Kogelberg State Forest.

a) Maintains a major reserve of the Cape Floristic Kingdom intact, conserving endemic vegetation, including rare and endangered species, as well as representative plant communities and ecosystems of scientific and educational interest.
b) Avoids destruction of wildlife habitat and disruption to interlinked ecosystems.
c) Avoids the introduction of invasive exotic plants and animals such as Australian Acacias and the Argentine Ant.
d) Avoids catchment erosion and river sedimentation from construction activities in the Palmiet Valley.

4E CONSERVES SCIENTIFIC AND EDUCATIONAL RESOURCES

Avoids inundation of potentially important research sites.

4F CONSERVES AGRICULTURAL LANDS

Avoids inundation of all agricultural land.

4G MAINTAINS NATURAL CONDITIONS IN THE PALMIET ESTUARY

Avoids possible impacts on estuarine organisms from releases of deoxygenated water and altered freshwater inflow.

4H CONSERVES AESTHETIC QUALITY OF THE KOGELBERG STATE FOREST

Preserves the natural beauty and pristine quality of the Kogelberg State Forest.

4I KEEPS FUTURE OPTIONS OPEN

Maintains options for future development or conservation programmes, including presently unknown potential uses of the Palmiet River Valley and its resources.

4J REDUCES FIRE HAZARD

Avoids increased risk of fires in the mountain region which would result from easier and more frequent public access.

4K AVOIDS ADVERSE IMPACTS ON LOCAL RESIDENTS

Prevents disruption to local communities from water storage construction activities.

4L CONSERVES RECREATIONAL RESOURCES IN THE PALMIET VALLEY AND AT STEENBRAS DAM

Maintains existing and potential recreational opportunities in Kogelberg State Forest, the Palmiet River and estuary, and at the Steenbras Dam.

ILLUSTRATIVE MATERIAL

APPENDIX II

Extract from Impact Report - Case Study 4 (Palmiet)

(Excerpted from Stauth and Lane, 1983, pp.20-25)

III CATEGORIES OF EFFECTS

Explanation

All potential benefits of the three water supply projects have been grouped under 18 categories of effects to facilitate discussion and comparison. A standard format is employed to assist the reader in finding the particular kind of information that is wanted. First, each category is identified (e.g. Effects on Reliability of Water Supply). Then each benefit that falls within that category is identified by its symbol, a notation further indicating which alternatives are being compared, and a descriptive heading (e.g. "1C - Dam/Weir: INCREASES RELIABILITY OF WATER SUPPLY", which refers to benefit C on list one, an advantage of the dam over the weir). The subsequent discussion of possible effects adheres to the following format: (1) general nature of the effects; (2) magnitude and probability of effects; (3) potential effects on social groups differently affected; (4) timing and duration of effects; and (5) possible secondary effects. The discussion is intended as a synopsis of fact and opinion available to the research team which could assist panelists in judging the relative significance of the benefits which have been identified.

Note:	1.	Dam/Weir	: Refers to advantages of dam over weir.
	2.	Weir/Dam	: Refers to advantages of weir over dam.
	3.	Dam/Desalination	: Refers to advantages of dam over desalination of sea water.
	4.	Desalination/Dam	: Refers to advantages of desalination of sea water over dam.

CATEGORY 1 : EFFECTS ON RELIABILITY OF WATER SUPPLY

1C - Dam/Weir: INCREASES RELIABILITY OF WATER SUPPLY

3E - Dam/Desalination: INCREASES RELIABILITY OF WATER SUPPLY

4A - Desalination/Dam: HASTENS DEVELOPMENT OF MORE SECURE WATER SUPPLIES

1.1 General Nature of the Effects

The net reliable yield of the dam is simply a function of the capacity of the dam, the surface area, and the net mean annual runoff. The yield of the weir, by contrast, depends on a system of pumps, tunnels, and canals to transfer water to storage in other parts of the catchment and other catchments. The storage capacity of the weir scheme is thus dependent on achieving high pumping rates during high flow periods, in order to avoid losses over the weir. This system is vulnerable to power shortages and mechanical breakdowns. ESCOM cannot provide assurances that power will always be supplied in the amounts needed, and equipment failures in the complex system could occur, so that the net reliable yield of the weir is relatively uncertain.

While the reliability of water supply from a dam is dependent largely on climatic variables, seawater desalination plants are independent of climatic considerations. Nevertheless, desalination plants are complex, energy-intensive systems which are subject to equipment failures from a variety of causes, from simple mechanical breakdowns, to sabotage and marine oil spills. The system is particularly vulnerable to interruptions in power supply and oil pollution in the coastal zone. The high energy cost and the limited availability of energy resources are major constraints in the implementation of desalination technology.

Water resources in the whole of South Africa are limited, and the country is subject to periodic droughts which affect large regions. Conventional water resources in the Greater Cape Town Region, even if fully developed, will be unable to meet expected demand much beyond 2012. Further growth and development of the Cape Town region will then be dependent on new, unconventional sources of water. These developments will affect the economic potential and security of the entire western Cape. Similarly, the development potential of the whole country is constrained by the availability of water, and to a large degree the country's political security is dependent on maintaining reliable supplies of water from internal sources.

Since desalination plants can be built in modular units, water planners can ensure that supply will keep pace with demand in each region. Desalination plants will be particularly useful in cushioning the impact of drought by reducing the drawdown of storage dams and serving as a last, irreducible source of water for the most critical needs of society when conventional sources become temporarily useless.

The early introduction of desalinated sea water into the country's water resource development strategy could lead to more rational use of this scarce resource by providing greater incentives (through higher water tariffs) for recycling and conservation measures. This would also reduce growth in demand, and so prolong the period of relatively reliable yields from conventional sources. This in turn would reduce the social, economic, and political risks associated with sudden, widespread water shortages. Finally, the early introduction of this technology would accelerate its development and could thus lower costs over the long term, since significant advances could be made before its widespread application is absolutely essential.

1.2 Magnitude and Probability of Effects

The net reliable yield from a dam is the quantity of water which can be abstracted on an annual basis with a low percentage risk of failure in supply. This yield will depend on the capacity and surface area of the dam, as well as the net mean annual runoff (runoff remaining after abstractions for agricultural use). The dam scheme has been designed to provide a net reliable yield of 104 million m^3/a (70% of the mean annual runoff) with a frequency of failure of not more than once in 50 years. The net reliable yield of the weir scheme would be 91 million m^3/a (59% of the net mean annual runoff). However, the probability of achieving this goal depends largely on the reliability of the pumps and the availability of sufficient power during peak demand periods. During extreme flood events, pumping rates would not keep up with inflow as the probable pumping capacity would be 6 m^3/s, and ESCOM has indicated that it may not always be possible to pump excess water. The amount of water which may be lost due to such failures could vary from 1 - 5 million m^3/a. The probability that losses at the upper end of this range would occur is considered to be low.

Desalinated water supply failures due to mechanical breakdowns or interruptions in power supply are likely to be rare and of such limited duration that other sources of supply can be used with little inconvenience. Although only about one week's supply of desalinated sea water would be kept in storage, water rationing measures could be taken in the event of prolonged breakdowns, and in the event of reactor problems, the desalination plant could be fed from the national grid. New energy sources (coal or nuclear) could be developed if needed.

In the case of major oil spills affecting the coastal zone, contamination of the intakes could halt all production for a matter of days or weeks, and this could lead to depletion of reserves from conventional water resources. The probability of such an event is considered to be very low: oil tanker accidents are rare, and desalination plants elsewhere (such as in the Persian Gulf) have never been seriously affected by oil pollution from accidents to tankers or wells. In the event of such an accident, however, oil pollution barriers could be erected and water conservation measures could be implemented to mitigate the impact.

Finally, the risks of failure in a desalination scheme may not be substantially greater than that of conventional schemes: purification works can fail, and dams and underground water sources can become contaminated, by both natural and man-caused processes.

The early introduction of desalination technology would conserve conventional water resources by increasing the supply of water both directly (desalinated sea water) and indirectly (providing incentives for re-use due to higher water tariffs), and by reducing the growth in demand (due to higher water tariffs). If desalination technology is delayed until conventional water resource projects are no longer able to meet the demand, water shortages are more likely to occur within the next 25 - 30 years. In addition, a rapid rise in water tariffs will occur toward the end of this period, but over a relatively short period of time, which could affect regional and national economic development. The possible magnitude of these effects has not been estimated, although risks associated with shortages and price hikes may increase exponentially as conventional water resources are exhausted, particularly if this corresponds with a period of drought.

There is an inconclusive debate over whether it is advantageous for South Africa to await technological improvements from experience overseas or to embark on its own programme in order to help bring about revolutionary developments and ensure that the country remains in the forefront of this new technology. The long-term effects of these two strategies on economic, social, and political factors cannot be accurately forecast.

1.3 Potential Effects on Social Groups Differently Affected

All social groups benefit from increased reliability of water supply, but higher income groups consume more water per capita and are likely to be more inconvenienced by interruptions in supply or when restrictions are placed on water use (such as bans on watering gardens, washing cars, etc.). In addition, future generations would presumably be appreciative of early investment in desalination technology to provide them with more reliable supplies of water.

1.4 Timing and Duration of Effects

All three projects would be completed in approximately 8 years from the start of construction. The dam would provide the most secure source of water in the short term, but this advantage would decline in importance as the proportion of conventional to desalinated water changes in favour of the latter and as desalination technology improves.

1.5 Possible Secondary Effects

The availability of a reliable water supply is a major consideration to individuals, commerce, and industry in deciding whether to locate in a particular region. In addition, a reliable water supply reduces the possibility of social and political tensions which could otherwise arise.

Perceptions as to the relative efficacy of the projects are difficult to assess; while the dam may be regarded as providing the most reliable source of water in the short term, the early introduction of desalination may be more attractive to persons with a long-term planning perspective. The early implementation of desalination technology could be a real confidence-building measure leading to stronger regional development. The eventual establishment of secure water supplies would result in a more stable and prosperous society in the future.

ILLUSTRATIVE MATERIAL

APPENDIX JJ

Final Listing of Impacts - Case Study 6 (Sandton)

(Excerpted from Grindley, 1988, pp.55-59)

6.3.1 Identification of Costs and Benefits

The Delphi panel identified the following 14 benefits and 16 costs associated with the three routes under consideration. Since all three routes had essentially the same impacts, differing only in degree, it was possible to use the same lists of impacts in the evaluation procedure.

<u>BENEFITS OF THE PROPOSED ROAD</u>

A. IMPROVED MOBILITY WITHIN SANDTON
The accessibility of certain areas in Sandton would be improved owing to the shorter and faster route provided by the road.

B. PEAK HOUR CONGESTION REDUCED
Traffic congestion would be reduced during morning and evening rush hours.

C. IMPROVED REGIONAL LINKS
Regional traffic flow would be improved.

D. REDUCED VEHICLE COSTS
The monetary costs of travel would be reduced because of less fuel consumption and wear and tear on vehicles.

E. IMPROVED ROAD SAFETY
Smoother traffic flow would reduce motor vehicle accidents and dangers to suburban residents.

F. IMPROVED QUALITY OF ENVIRONMENT ALONG EXISTING NEIGHBOURHOOD ROADS
There would be reduced levels of noise and air pollution in neighbourhoods now subject to "rat-running".

G. REDUCED ROAD MAINTENANCE COSTS

Maintenance costs of suburban roads should decrease if "rat running" traffic is reduced.

H. INCREASED GROWTH AND PROSPERITY

An improved transportation system would stimulate development and increase property values.

I. POTENTIAL FOR DEVELOPMENT AT GOLF CLUB SITE

Improved access to the River Club Golf Course property could make it a more desirable site for future development.

J. INCREASED JOB OPPORTUNITY

Construction of the new road could increase the number of jobs available in the area.

K. ADDITIONAL SERVITUDES

The road corridor would provide a convenient servitude for placing public utilities.

L. IMPROVEMENT OF BRAAMFONTEIN RIVER TRAIL

Mitigation measures could improve the environmental quality of the spruit trail.

M. IMPROVEMENT OF RIVER CLUB SPRUIT

Mitigation measures for Routes 3 and 4 would include the rehabilitation of River Club Spruit.

N. IMPROVED COHERENCE OF URBAN LANDSCAPE

The public's understanding of the way the city is structured could be improved by the addition of a new route.

COSTS OF THE PROPOSED ROAD

A. REDUCED VALUE OF SANDTON FIELD AND STUDY CENTRE

The visual, noise, air pollution and physical impacts of a road would adversely affect the special ambience, recreational value and conservation significance of the Sandton Field and Study Centre (SF&SC).

B. REDUCED VALUE OF BRAAMFONTEIN SPRUIT TRAIL

The visual, noise and physical impacts of a road would adversely affect the special ambience, recreational value and conservational significance of the Braamfontein Spruit Trail.

C. INCREASED POLLUTION IMPACTS IN CERTAIN NEIGHBOURHOODS

Neighbourhoods along the route would experience greater noise levels, visual intrusion and air pollution.

D. REDUCED PROPERTY VALUES

The value of properties adjacent to the road may decline, and there would be a loss of rates in Sandton.

E. CHANGE IN COMMUNITY CHARACTER, COHESION AND SAFETY

Certain communities would be altered in character, cut off physically and psychologically from their neighbours, and exposed to more safety hazards.

F. INCONVENIENCES DURING CONSTRUCTION

Construction activities would cause noise, dust and delays during the construction period.

G. REDUCED AMENITY VALUE OF THE RIVER CLUB GOLF COURSE

The pleasant and tranquil atmoshpere of the Golf Course would be adversely affected by the proximity of the road.

H. POTENTIAL LOSS OF OPEN SPACE

There is a possibility that the River Club Golf Course would decide to relocate and develop the present facility for housing.

I. EFFECT ON MORNINGSIDE CLINIC

Morningside clinic would be adversely affected by the proximity of a major arterial.

J. LOSS OF PROPERTY AND DEVELOPMENT RIGHTS

Certain properties would be expropriated and others would lose their development rights.

K. REDUCED HOUSING STOCK

Demolition of houses within the road corridor would result in a slight reduction in the availability of housing in Sandton.

L. FINANCIAL COSTS

Financial resources would be required for construction of the road, bridging, mitigation measures and expropriation costs.

M. EFFECTS ON RIVER CLUB SPRUIT

The amenity value of River Club Spruit may be reduced.

N. DECREASE IN OVERALL QUALITY OF ENVIRONMENT BEYOND THE IMMEDIATE ENVIRONS OF THE ROAD

Sandton could suffer a general decrease in environmental quality.

O. REDUCED INCENTIVE TO IMPROVE PUBLIC TRANSPORT FACILITIES

The construction of more roads would discourage the provision of public transport.

P. CONFIDENCE IN THE LOCAL AUTHORITY THREATENED

Controversy and bitterness over the road could weaken the confidence and trust that ratepayers have in the local authority and divide the community.

An investigation was undertaken to describe the implications of each of these costs and benefits for each of the routes in a report called the "Delphi Briefing Document" (see Volume 2, Supplementary Report 10). This report was scrutinized for adequacy and completeness by representatives of Sandton Town Council and affected parties (see Volume 2, Supplementary Report 8, Section 8.2), and then given to the Delphi panelists to read before the evaluation meeting.

ILLUSTRATIVE MATERIAL

APPENDIX KK

Extract from Delphi Briefing Document - Case Study 6
(Sandton)

(Excerpted from Stauth and Grindley, 1988, pp.13-31)

BENEFITS OF THE PROPOSED ROAD

A. IMPROVED MOBILITY WITHIN SANDTON

The accessibility of certain areas in Sandton would be improved owing to the shorter and faster route provided by the road.

Affected Groups

Motorists and Sandton residents.

Description of the Benefit

East-west vehicular access across Sandton would be enhanced and there would be improved access to local shopping centres, working areas and the CBD.. All three routes would offer a similar degree of accessibility to Sandton residents.

Magnitude of the Benefit

At present, there are several routes that motorists can take between Rivonia Road (at South Road) and Peter Place. It is estimated that about one kilometre in distance, and from one to three minutes in time, could be saved by motorists using this new corridor. There would be no material difference in time saving between the three routes. The total length of this east-west link would be:

3,85 kilometres for Route 2;

4,30 kilometres for Route 3; and

4,05 kilometres for Route 4.

B. PEAK HOUR CONGESTION REDUCED

Traffic congestion would be reduced during morning and evening rush hours.

Affected Groups

Commuters from Randburg and Sandton to Sandton CBD and Wynberg industrial area.

Description of Benefit

Commuters would have less travel time between Randburg, Sandton and Wynberg, and future traffic congestion levels would not be as high. Commuting would be less tiring and frustrating.

Approximately 90 taxis travel to Sandton and Wynberg from Alexandra. The chairman of the Alexandra Taxi Association (ATA) claims that traffic congestion is at its worst on the William Nicol Drive between Peter Place and Sandton. The proposed road would divert some traffic away from William Nicol Drive, and would therefore alleviate traffic congestion there.

Magnitude of Benefit

At present, there are several routes that commuters can take during rush hour between Rivonia Road (at South Road) and Peter Place. The new route is designed to accommodate about 2 000 cars per hour in each direction at a high level of service. Commuting time would be reduced on any one of the proposed routes during peak hours but the time saving has not been estimated. The time savings for commuters would be approximately the same for each of the three proposed routes.

It is likely that William Nicol Drive and other routes will be upgraded to improve their capacity when they become more congested, and this would offset the benefits of the new road. Currently about 3 500 vehicles per hour use William Nicol Drive and this exceeds design capacity. According to a traffic engineering report (updated in 1988), if improvements to traffic circulation are not made by 2001 the theoretical peak hour number of vehicles on William Nicol Drive could be up to 5 000 vehicles per hour. There would thus be increased delays and the peak hour period would be extended.

COSTS OF THE PROPOSED ROAD

A. REDUCED VALUE OF SANDTON FIELD AND STUDY CENTRE

The visual, noise, air pollution and physical impacts of a road would adversely affect the special ambience, recreational value and conservation significance of the Sandton Field & Study Centre (SF&SC).

Affected Groups

Users of the SF&SC and conservationists.

Description of Cost

The SF&SC has been conserved through the efforts of such organisations as the Transvaal Division of Nature Conservation, Sandton Town Council Parks and Recreation Division, and the Co-ordinating Committee for Community Open Space (COCCOS). It is the policy of these organisations to promote the continued conservation, maintenance and upgrading of this area, including the pioneer farmhouse, graveyard, store and post office, and SF&SC building.

Route 2, aligned along the northern edge of the SF&SC is the only route that would take land from the SF&SC. Nonetheless, Route 4 would take public open space that lies between SF&SC and the golf course, and is currently managed as an integral part of the SF&SC. These routes would cross the Braamfontein Spruit with bridges 90 and 180 metres long respectively, and would also have visual and noise impacts on the SF&SC.

Route 3 would cross the spruit 250 metres north of the SF&SC and would therefore have less visual and noise impact than would Routes 2 and 4. If either Routes 2 or 4 were built, it would not be possible to extend the SF&SC up to Peter Place.

Noise and visual intrusion of the road and bridge over the spruit, and exhaust fumes from vehicles, would decrease the environmental and aesthetic quality of the area for users of the SF&SC wishing to escape from the stresses of the urban environment. Fragmentation of the centre would reduce its amenity value, and degradation of environmental quality would decrease the centre's value as a venue for educational activities, exhibitions and fairs. Construction of a road through the centre would also violate the symbolic significance of the SF&SC to many people in Sandton.

From a regional point of view, the SF&SC does not compare favourably to parks such as Gillooly's Farm, Zoo Lake, Bezuidenhout Park, and Delta Park as it lacks size as well as facilities. The SF&SC is, however, the best park in Sandton according to a recent survey done by a landscape architect. Of 17 parks and public open spaces in Sandton, the SF&SC rated highest in terms of recreational and aesthetic qualities, and fifth in ecological quality. In a comparative evaluation of the overall quality of open spaces in Sandton, taking into account ecological value, aesthetic value and recreation value and amenities, the top-rated open spaces were SF&SC and the Ernest Ullman Community Centre.

The principal value of the SF&SC is its recreational function. The size of the open space (21 hectares), the gentle slope of the landscape, the presence of large exotic and smaller indigenous trees as well as open areas, present opportunities for a great variety of outdoor recreational activities. Furthermore, the SF&SC forms a link in the linear open space system and plays a critical role in the river trail system of Sandton.

The main ecological value of the SF&SC lies in the fact that the park forms a segment in a chain of open spaces situated along the river valley. According to the consulting ecologist, the ecological importance of this area is that it forms part of a corridor through the built-up area of Sandton where the only continuous space is that along the water courses. Nevertheless, none of the routes would constitute a physical barrier to wildlife movements or eradicate any critical wildlife habitat.

Magnitude of Cost

Route 2 would take 1,2 hectares of the northern sector of the SF&SC and isolate a further 2 hectares. Route 4 would alienate an area of about 1 hectare, whereas Route 3 would not take any land.

Sound levels or noise can be measured in terms of decibels (dB) which reflect different levels of sound pressure. The unit "dBA" is a weighted measurement of sound that is most commonly used for measurement at all sound levels. Current background noise in the northern region of the SF&SC is 49dBA, and south of the car park is 46dBA, due to the proximity of William Nicol Drive. These prevailing sound levels are already in excess of the 45dBA recommended by the South African Bureau of Standards (SABS) for recreational areas. Surrounding topography may significantly affect dBA values, but where there is level ground the following noise levels are anticipated at different distances from the edge of the road, based on the 1986 traffic counts for a design speed of 80km/h.

Without mitigation, Route 2 would produce a noise level of 56dBA at the SF&SC building (an increase of 7dB over prevailing noise levels), increasing to 70dBA at a distance of 20 metres from the new road. The effect of Route 3 on the noise level at the SF&SC would be of the order of 3dB. Route 4 would produce a noise level intermediate between those expected for Routes 2 and 3.

With the planned mitigation of a 4m berm, noise levels should be as follows:

Distance(m)	50	100	200	300
Noise level (dBA)	50	47	44	43

It has been found that a 5dB increase in the level of noise leads to sporadic complaints, whereas a 10dB increase causes widespread complaints. Increases above these levels cause a strong response and threats of community action.

Mitigation of Cost

The impacts to the SF&SC could be mitigated by the development of 15 morgen of land adjacent to the SF&SC on the south (portion 34), which is being purchased for R800 000 by Sandton Town Council. This addition, which can become an integral part of the park, presently consists of undeveloped, open land which borders the Braamfontein Spruit on the east bank; it is not as well treed as the rest of the SF&SC.

Measures which would be taken to mitigate the visual and noise impacts of the road include:

(1) shaping cuts and fills into natural contours;

(2) planting these contoured surfaces with screening vegetation; and

(3) creating berms along the route.

The construction of a 4m berm would reduce the noise level by 12dB at 50m from the edge of the road. To gain this measure of mitigation the berm would have to be designed so that no buildings or play areas have direct line of sight of the road.

Where the route is not in a cut, berms need to be built to ensure that the land adjacent to the road is at least 4m in height. This action would reduce the noise level at a distance of 100 metres from the road to the existing noise levels. Thus the impact of the road with mitigation would at a minimum affect not only the 1,2 hectares expropriated, but also an additional one hectare along each side of the road for every 100 metres of road length.

Where the road crosses the river it would be difficult to mitigate the noise. If this is so, then the noise would affect a further 4 hectares. Noise and visual impacts from bridges on all three routes could be partially mitigated by berms along the approaches and dense planting of trees on these berms. The placing of noise screens along the bridge would create a man-made visual barrier 4 metres high by about 90 metres long.

Routes 2 and 4 would have similar noise impacts on the SF&SC. Noise effects from Route 3 would be minimal.

B. REDUCED VALUE OF BRAAMFONTEIN SPRUIT TRAIL

The visual, noise and physical impacts of a road would adversely affect the special ambience, recreational value and conservation significance of the Braamfontein Spruit Trail.

Affected Groups

Conservationists and walkers/joggers.

Description of Cost

All three routes would cross the Braamfontein Spruit Trail. This trail is part of a proposed continuous green belt of linear parkways extending through the metropolitan area. Organisations actively concerned with the conservation and development of this trail system include COCCOS and the Braamfontein Spruit Trust.

All three routes would reduce the continuity of the linear parkway and the recreation potential of the trail. Route 2 would cross the Braamfontein Spruit at the SF&SC, which is where walkers/joggers normally begin or end their journey. Route 3 would cross the spruit and trail about 250 metres north of the SF&SC boundary. Route 4 would start at the River Club Golf Course boundary and stretch for 200 metres to the south. The long, angled bridge of Route 4 would have greater visual and noise impacts on walkers/joggers than the other routes.

The noise and visual intrusion of the road and bridge over the spruit could decrease the environmental and aesthetic quality of the area for walkers/joggers wishing to escape from the stresses of the urban environment. The Braamfontein Spruit Trail is the longest linear park in the Republic. Bisection of the Braamfontein Trail by another bridge would reduce the scenic beauty of the trail, and the loss of serenity could adversely affect the enjoyment that walkers/joggers get from this facility. Animal movements along the river should not be affected, and no critical riverine habitat should be lost.

Magnitude of Cost

EFFECT	UNIT	ROUTE 2	ROUTE 3	ROUTE 4
Length of bridge	m	90	60	180

The noise impact would be similar to that discussed for the SF&SC in the previous section. There are already 16 vehicular crossings along the length of this trail. Users of the trail would take about 3 to 5 minutes to pass through the zone of noise and visual disturbance created by any of these routes.

Mitigation of Cost

Mitigation measures would include such actions as reinstating indigenous vegetation, and ensuring that animal movement and critical habitat are not affected. Measures which would be taken to mitigate the visual and noise impacts of the road would be similar for all three routes and would include:

(1) shaping cuts and fills into natural contours;

(2) planting these contoured surfaces with screening vegetation; and

(3) creating berms along the route.

ILLUSTRATIVE MATERIAL

APPENDIX LL

Estimated Net Value of Mining - Case Study 1 (Groenrivier)

(Excerpted from Stauth, 1982b, pp.52-56)

Discussions with Mr Bentley, Planning Manager for De Beers Namaqualand, indicated that set-up costs for the initial surf prospecting/mining operation based at Groenrivier would be approximately R1 million, and annual operating costs would be about R400 000. This would provide equipment and facilities for a crew of 20 (including 6 divers) supporting one mobile treatment plant.

The following table presents a profitability analysis of a hypothetical surf prospecting/mining operation for a 10 km stretch of coast, based on estimates provided by Mr Hazel and Mr Bentley.

TABLE 1

Size of Ore Body	20 000 m^3
Grade of Ore	2 carats/m^3
Total Carats	40 000
Revenue per Carat	R150
Total Revenue	R6 million
Treatment Rate	10^3/day
Time to Mine	7 years
Capital Investment	R1 million
Operating Costs	R400 000/year
Total Costs	R3,8 million

Assuming the original capital investment is made on day one of the fiscal year, and operating costs and revenues are recorded monthly, a present value analysis by period reveals that the net present value of the operation when the project is completed is R1 325 979, as shown in Table 2 below.

TABLE 2

Time Period	Investment (Outlays)	Benefits (Inflows)	Present Value Factor at 10%	Present Values
0	R1 000 000	-	1,000	-R1 000 000
1	400 000	R857 150	0,950	+ 434 293
2	400 000	857 150	0,864	+ 394 978
3	400 000	857 150	0,785	+ 358 863
4	400 000	857 150	0,714	+ 326 405
5	400 000	857 150	0,649	+ 296 690
6	400 000	857 150	0,590	+ 269 719
7	400 000	857 150	0,536	+ 245 032
	R3 800 000	R6 000 050		R1 325 979

Mr Magrath, Assistant General Manager of De Beers Namaqualand Division, felt that the revenue per carat for this operation was more likely to be about R50/carat, and the treatment rate would be closer to $20m^3$/day, so that the project would generate less revenue but total costs would be less and income would be received sooner. Table 3 below presents a profitability analysis for this scenario.

TABLE 3

Time Period	Investment (Outlays)	Benefits (Inflows)	Present Value Factor at 10%	Present Values
0	R1 000 000	-	1,000	-R1 000 000
1	400 000	R500 000	0,950	+ 95 000
2	400 000	500 000	0,864	+ 86 400
3	400 000	500 000	0,785	+ 78 500
4	400 000	500 000	0,714	+ 71 400
	R2 600 000	R2 000 000		- R 668 700

According to this analysis, surf mining will be unprofitable.

The third profitability analysis is based on projections made by Mr Cornelissen, Chief Geologist for Dawn Diamonds, who feels that it would not really be profitable for De Beers to undertake surf prospecting unless it was anticipated that it may be possible to operate on a fairly large scale for an extensive period. This would likely involve the use of at least 10 to 20 mobile treating plants over a 10 to 20 year life. Mr Cornelissen believes that De Beers' projections on the grade of ore is too optimistic, and it will be necessary to mine approximately 2 million m^3 of ore. He also feels that the revenue per carat in this area is unlikely to be over R35. Mr Cornelissen's projections for this larger-scale surf mining operation are illustrated in Table 4 below.

TABLE 4

Size of Ore Body	4 million m^3
Grade of Ore	0,5 carat m^3
Total carats	2 million
Revenue per Carat	R35
Total Revenue	R70 million
Treatment Rate	700 m^3/day
Time to Mine	20 years
Capital Investment	R1,9 million (year 0)
	R1,0 million (year 5)
	R1,0 million (year 10)
	R1,0 million (year 15)
Operating Costs	R1 440 000/year
Total Costs	R33 700 000

Table 5 below presents a profitability analysis for Mr Cornelissen's forecast.

TABLE 5

Time Period	Investment (Outlays)	Benefits (Inflows)	Present Value Factor at 10%	Present Values
0	R1 900 000	-	1,000	-R1 900 000
1	1 440 000	R3 500 000	0,950	+ 1 957 000
2	1 440 000	3 500 000	0,864	+ 1 779 840
3	1 440 000	3 500 000	0,785	+ 1 617 100
4	1 440 000	3 500 000	0,714	+ 1 470 840
5	2 440 000	3 500 000	0,649	+ 687 940
6	1 440 000	3 500 000	0,590	+ 1 215 400
7	1 440 000	3 500 000	0 536	+ 1 104 160
8	1 440 000	3 500 000	0,488	+ 1 005 280
9	1 440 000	3 500 000	0,443	+ 912 580
10	2 440 000	3 500 000	0,403	+ 472 180
11	1 440 000	3 500 000	0,366	+ 753 960
12	1 440 000	3 500 000	0,323	+ 665 380
13	1 440 000	3 500 000	0,303	+ 624 180
14	1 440 000	3 500 000	0,275	+ 566 500
15	2 440 000	3 500 000	0,250	+ 265 000
16	1 440 000	3 500 000	0,227	+ 467 620
17	1 440 000	3 500 000	0,207	+ 426 420
18	1 440 000	3 500 000	0,188	+ 387 280
19	1 440 000	3 500 000	0,171	+ 350 200
20	1 440 000	3 500 000	0,155	+ 319 300
	R33 700 000	R70 000 000		R15 148 160

According to Mr Cornelissen's projections, the net present discounted value of the surf mining option (using a 10% discount rate) is R15 148 000.

ILLUSTRATIVE MATERIAL

APPENDIX MM

Estimated Net Value of Stock Farming - Case Study 1
(Groenrivier)

(Excerpted from Stauth, 1982b, pp.39-40)

CHAPTER FIVE

THE INTERNAL COSTS AND BENEFITS OF SELECTED DEVELOPMENTS

The internal costs and benefits projected for the four management options are presented below.

1. STOCK FARMING

Attempts to obtain actual financial data for the specific farms in question were not successful. Most farmers do not keep accurate records, or are reluctant to discuss financial matters. A form was designed and translated into Afrikaans to be distributed to De Beers tenant farmers through the Farm Manager (see Appendix O of Report 1), but unfortunately it was considered too complex and time-consuming and was not forwarded to the farmers. Similar problems were encountered in getting estimates from the local extension officer. Forms to be provided at a farmers' meeting were not distributed due to an oversight, and a farming profitability study which was to have been concluded by December 1981 was delayed.

It was then decided to use farming data gathered by the Department of Agricultural Economics and Marketing in the Bitterfontein area to estimate the value of farms and farming along the coast. This department monitors farm production, income and expenditures for selected farms in the Cape. Several farms in the Bitterfontein area participate in this study, and three coastal farms were selected for analysis. According to Mr Laubscher, Agricultural Economist studying this group, these farms probably have more potential for agricultural production than do farms in the Groenrivier-Spoegrivier area. Yet total farm expenditure for farms in this study group in recent years has exceeded gross income from livestock and crops, and farmers have been relying on other income (subsidies, outside jobs, salt production, sale of equipment, etc.) to make a living. For example, in 1979/1980, the average income from livestock and crops was R20 097 and the average expenditure was R22 022. Additional income (from contract work, subsidies received, profit on sale of capital items) averaged R6090, and stocks on hand averaged R201, to yield a net farm income (NFI) of R4366. Even with this additional income (not all of which should be included in a social cost-benefit analysis), NFI was only R3,83 per R100 of capital investment, and only R0,74 per ha. In 1980/1981, average NFI dropped further to R459, or R0,28 per R100 of capital investment, and R0,08 per ha.

Although drought conditions have limited yields in recent years, Mr Laubscher feels that the agricultural potential of the area has deteriorated due to overstocking and these farms are no longer really viable. Transport costs are now higher, and yields are declining, so that expenditure has overtaken income and farmers are living off subsidies, savings, and outside income. It seems unlikely that their children will continue farming operations.

ILLUSTRATIVE MATERIAL

APPENDIX NN

Estimated Net Value of National Park - Case Study 1
(Groenrivier)

(Excerpted from Stauth, 1982b, pp.92-93)

COST PROJECTIONS FOR THE NATIONAL PARK

The cost of developing and operating a national park at Groenrivier was estimated by projecting the expenditure pattern of the Tsitsikamma Park over the next 50 years. Forecasts for the first 18 years were derived by inflating the actual costs of Tsitsikamma Park (from its beginning 18 years ago) to present values using the national building cost index (1982 value = 450). The annual increase in expenditure from the 19th year reflects the average real growth in expenditure for Tsitsikamma Park over the past 10 years - 7,7% per annum.

Since the Tsitsikamma data were not complete, it was necessary to accept approximate expenditures for certain years (65-66, 66-67, 70-71, and 72-73) and estimate expenditures by interpolation for the period 73-77.

The following table illustrates the cost projection procedure. Land acquisition costs (in year zero) are assumed to be R1 700 000. Future costs are discounted at 10% to obtain present value equivalents.

Tsitsikamma Year	Tsitsikamma Expenditure	Building Cost Index (1982 = 450)	Cost inflated to Present Value	Groenrivier Year	Present Value at 10%
-	-	-	-	1982 - 83	R1 700 000
1963 - 64	R5 075	68	R33 585	1983 - 84	31 906
1964 - 65	21 238	75	127 428	1984 - 85	110 098
1965 - 66	16 984	78	97 985	1985 - 86	76 918
1966 - 67	50 954	80	286 616	1986 - 87	204 644
1967 - 68	63 473	82	348 327	1987 - 88	226 064
1968 - 69	73 570	85	389 488	1988 - 89	229 798
1969 - 70	79 529	93	384 817	1989 - 90	206 262
1970 - 71	85 970	102	379 279	1990 - 91	185 088
1971 - 72	104 880	124	380 613	1991 - 92	168 612
1972 - 73	115 368	125	415 325	1992 - 93	167 376
1973 - 74	163 013	140	523 970	1993 - 94	191 773
1974 - 75	210 659	164	578 028	1994 - 95	186 703
1975 - 76	258 304	185	628 307	1995 - 96	190 377
1976 - 77	305 950	201	684 963	1996 - 97	188 365
1977 - 78	353 595	206	772 416	1997 - 98	193 104
1978 - 79	316 454	213	668 565	1998 - 99	151 764
1979 - 80	446 999	250	804 598	1999 - 00	166 552
1980 - 81	532 470	317	755 872	2000 - 01	142 104
-	-	-	814 074	2001 - 02	139 207
-	-	-	876 758	2002 - 03	135 897
			etc	etc	etc

With costs increasing at 7,7% per annum from the year 2000 - 01, the total present value of park costs will be R7 198 000 as of the year 2032 - 33.

ILLUSTRATIVE MATERIAL

APPENDIX OO

Evaluation of the Nonmonetizable Costs of the Three Options
- Case Study 1 (Groenrivier)

(Excerpted from Stauth, 1982b, pp.94-101)

SURF MINING AND STOCK FARMING

vs

NATIONAL PARK

Stock farming would be compatible with surf mining but the present recreational usage of the campground would be excluded. The surf mining and stock farming option yields the higher monetary benefit (none of the benefits of the national park have been monetized). However, this option involves the following, potentially significant, nonmonetizable costs:

A. Soil structure and fertility would continue to deteriorate as a result of overgrazing in dry periods.

B. The unsightly campground would probably remain as a blemish on an otherwise attractive setting and would be used by the mining crews.

C. The lagoon would continue to be degraded by dust pollution and gravel originating from erosion of the road and campground.

D. Dust and sand damage to vegetation would result from heavy traffic on the gravel roads, and more direct impacts on the vegetation would occur from off-road traffic and gravel treatment activities.

E. The opportunity to provide hiking trails and other recreational benefits for the national population would be foregone. (There are no parks on the west coast and no reserves north of Lambert's Bay, and few areas have potential for being declared a reserve or park in this part of Namaqualand.)

F. Kelp and sediment removal could reduce productivity of the coastal marine ecosystem by disrupting nutrient cycling, food chains, and natural habitat.

G. Sediment dispersion could smother mussel beds and reduce the rock lobster population. The rock lobster resource could also be significantly reduced by direct impacts such as sucking up larvae by pumps and lobster exploitation by mining crews.

H. Coastal features and ecosystems would be altered, and some endemic species could be further endangered.

I. The natural beauty of the area could be significantly degraded by (1) the establishment of roads, tracks, and quarries along the coastal fringe; (2) excavating beach deposits and dumping wastes on or near the beaches; and (3) other disturbances which lead to erosion and loss of vegetation.

J. The pristine or wilderness quality of the natural setting could be significantly diminished by highly visible scars in the sensitive coastal zone.

K. The value of the area as a repository of cultural and historic resources (such as strandloper midden deposits), and as a "natural laboratory" offering opportunities for scientific studies, would be impaired.

L. The value of the area as a "natural classroom" for further environmental education would be reduced.

M. The value that people attach to leaving their natural heritage to their children and future generations would be substantially lost.

N. The value that people attach to simply knowing that some parts of nature remain undisturbed even if they may never visit such areas, would be lost.

O. Irreversible changes to the coastal environment would reduce land-use options remaining to present and future generations.

The potentially significant nonmonetizable costs of a national park are as follows:

A. About 20 farmers and their families would be displaced. Some might have to find another livelihood, and longstanding associations with the land and the local community could be lost.

B. Visitors would no longer be allowed to collect bait organisms, catch rock lobsters, or exploit other natural resources in the area.

LOCAL RECREATION AND STOCK FARMING

vs

NATIONAL PARK

None of the benefits of the national park have been monetized; the local recreation and stock farming option yields the higher monetary benefit. However, this option involves the following, potentially significant, nonmonetizable costs:

A. Soil structure and fertility would continue to deteriorate as a result of overgrazing in dry periods.

B. The unsightly campground would probably remain as a blemish on an otherwise attractive setting.

C. The lagoon would continue to be degraded by dust pollution and gravel originating from erosion of the road and campground.

D. Recreationalists would probably continue to overexploit the local rock lobster resource.

E. Dust and sand damage to vegetation would continue from traffic on the gravel road, and from dune buggies, trampling, and grazing pressures in the semi-vegetated dunes.

F. Opportunities for approximately 100 jobs which would be created by the establishment of a national park, would be foregone.

G. Multiplier effects on the local economy (the Garies region in particular) would be foregone.

H. The opportunity to provide hiking trails and other recreational benefits for the national population would be foregone. (There are no parks on the west coast and no reserves north of Lambert's Bay, and few areas have potential for being declared a reserve or park in this part of Namaqualand.)

The potentially significant nonmonetizable costs of a national park are as follows:

A. Farmers and their families would be displaced. Some might have to find another livelihood, and longstanding associations with the land and the local community would be lost.

B. Visitors would no longer be allowed to collect bait organisms, catch rock lobsters, or exploit other natural resources in the area.

C. The descendants of the local population would be deprived of the exclusive use of this traditional holiday area.

D. People who prefer "undeveloped" and generally "unknown" retreats to more organized and more popular holiday places will lose another relatively unspoiled area.

LOCAL RECREATION

vs

SURF MINING

The surf mining option yields the higher monetary benefit. However, this option involves the following, potentially significant, non-monetizable costs:

A. The descendants of the local population would be denied the opportunity to enjoy this traditional holiday area.

B. Casual visitors in search of undeveloped retreats would lose one of the most unspoiled areas remaining in Namaqualand.

C. Kelp and sediment removal could reduce productivity of the coastal marine ecosystem by disrupting nutrient cycling, food chains, and natural habitat.

D. Sediment dispersion could smother mussel beds and reduce the rock lobster population. The rock lobster resource could also be significantly reduced by direct impacts such as sucking up larvae by pumps and exploitation by mining crews.

E. Coastal features and ecosystems would be altered, and some endemic species could be further endangered.

F. The natural beauty of the area could be significantly degraded by (1) the establishment of roads, tracks, and quarries along the coastal fringe; (2) excavating beach deposits and dumping wastes on or near the beaches; and (3) other disturbances which lead to erosion and loss of vegetation.

G. The pristine or wilderness quality of the natural setting could be significantly diminished by highly visible scars in the sensitive coastal zone.

H. The value of the area as a repository of cultural and historic resources (such as strandloper midden deposits), and as "natural laboratory" offering opportunities for scientific studies, would be impaired.

I. The value of the area as a "natural classroom" for furthering environmental education would be reduced.

J. The value that people attach to leaving their natural heritage to their children and future generations would be substantially lost.

K. The value that people attach to simply knowing that some parts of nature remain undisturbed, even if they may never visit such areas, would be lost.

L. Irreversible changes to the coastal environment would reduce land-use options remaining to present and future generations.

The potentially significant nonmonetizable costs of local recreation are as follows:

A. Opportunities for approximately 100 jobs would be foregone.

B. Multiplier effects on the local economy (the Garies region in particular) would be foregone.